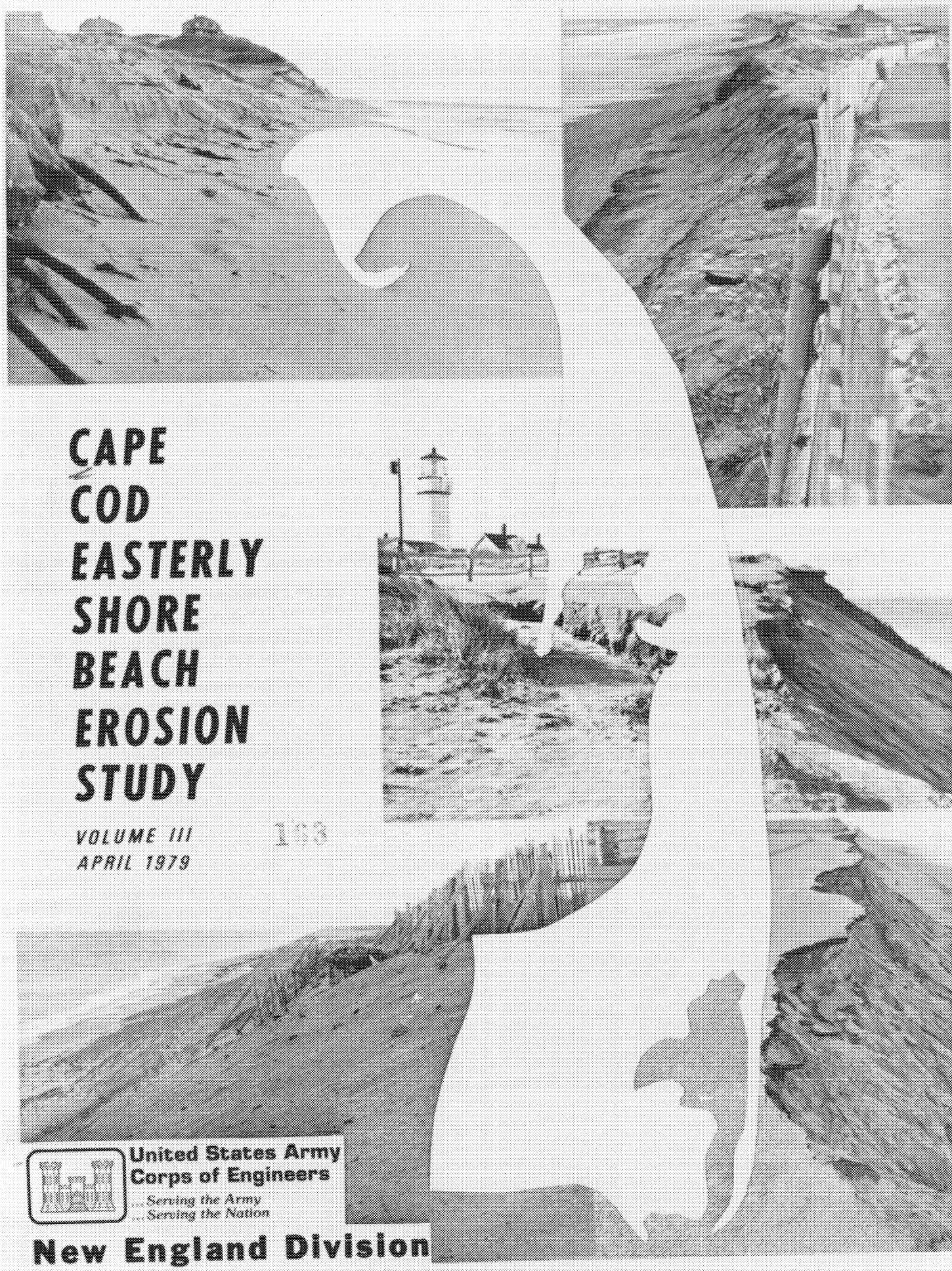

CAPE COD EASTERLY SHORE BEACH EROSION STUDY

VOLUME III
APRIL 1979

United States Army
Corps of Engineers
... Serving the Army
... Serving the Nation

New England Division

PROVINCETOWN

PROVINCETOWN HARBOR

PROVINCETOWN TRURO

NORTH TRURO

PAMET R.

TRURO

SOUTH TRURO

TRURO WELLFLEET

WELLFLEET

SOUTH WELLFLEET

WELLFLEET HARBOR

WELLFLEET EASTHAM

NORTH EASTHAM

EASTHAM

EASTHAM ORLEANS

ORLEANS

ORLEANS BREWSTER

BREWSTER

Nickerson State Park

ORLEANS CHATHAM

PLEASANT BAY

HARWICH

CHATHAM

CAPE COD BAY

ATLANTIC OCEAN

STUDY LIMITS

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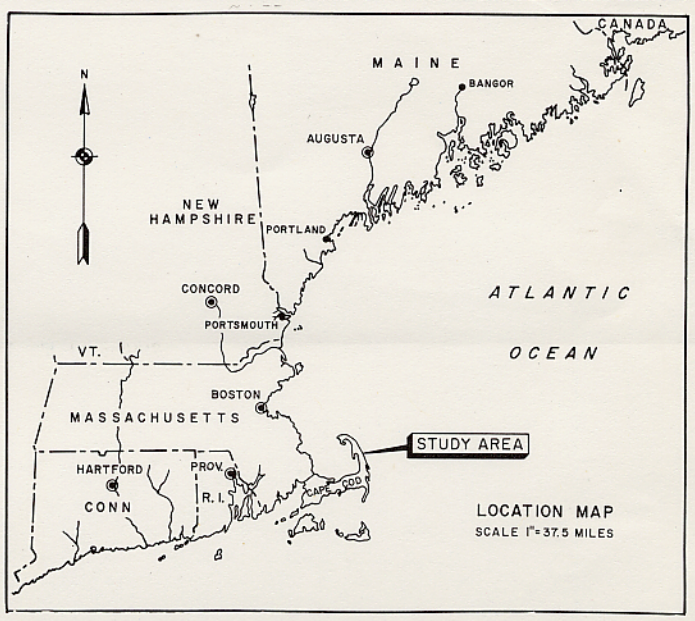

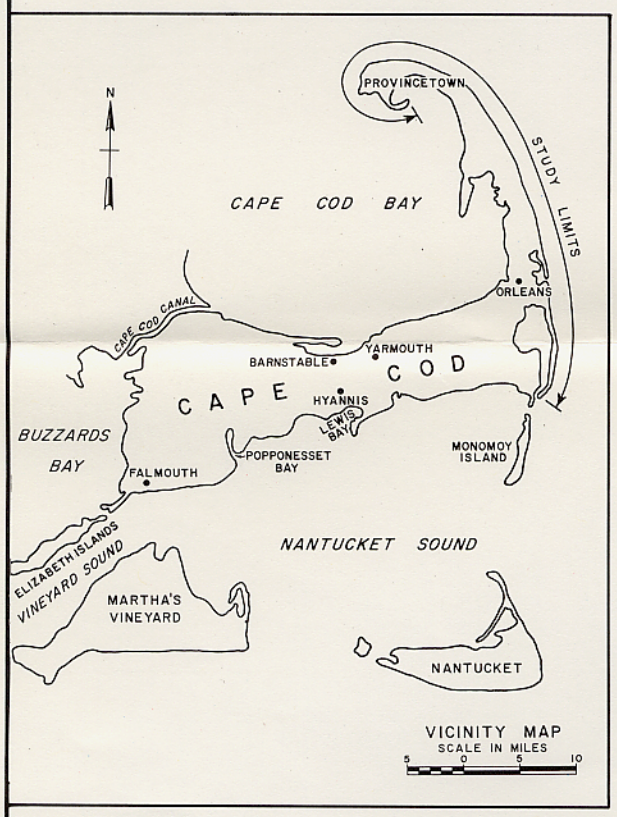

LEGEND

- FEDERAL
- PRIVATE
- TOWN
- PARK BOUNDARY

BEACH EROSION CONTROL STUDY

CAPE COD EASTERLY SHORES

CAPE COD, MASSACHUSETTS

LOCATION MAP

SCALE IN MILES

1 1/2 0 1 2 3

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

INTRODUCTION

The Corps of Engineers has been directed to make a survey of the easterly shores of the outer arm of Cape Cod, Massachusetts, extending from Provincetown to the southern extremity of Nauset Beach in the interest of beach erosion control, hurricane protection and allied purposes. The survey was authorized by a resolution adopted by the Committee on Public Works of the House of Representatives on 2 December 1970. The report is divided into three volumes: Volume I, Main Report; Volume II, Technical Report; and Volume III, Reconnaissance Reports. Although the Corps was unable to justify financial participation in shore protection along the easterly shore, we have tried to compile background information, both technical and non-technical.

The above-mentioned volumes and discussion are designed to assist other federal agencies and state and local interests in future development and management of the popular Cape Cod easterly shore. The recommendations suggested in this report are for consideration by individual towns and by the National Park Service to assist them in retarding the erosion along the shore.

PREFACE

This volume of the report consists of individual reconnaissance reports for each town and the National Park Service. The reports briefly describe the area, placing special emphasis on public use beach areas, and recommend solutions for local interests to implement, along and behind the shoreline, to try to enhance the area and reduce the rate of erosion. Any non-structural plan of improvement recommended, or any considered suggestion, should not be implemented until a detailed study is undertaken to assure that the recommended plan for the area is the most practical, economical and environmentally sound method of solving the problem. For specific details on shore history, tides, shoreline and offshore depth changes, etc., refer to Volume II of this report.

ACKNOWLEDGMENTS

This report was made under the direction of:

John P. Chandler, Colonel, Corps of Engineers, Division Engineer

Joseph L. Ignazio, Chief, Planning Division

It was completed under the supervision of Mr. Oscar Arpin, former Chief, Coastal Development Branch; Mr. Donald Martin, Chief, Coastal Development Branch. Mr. Thomas C. Bruha, Project Manager, developed the report, and Analysis & Technology, Inc., of North Stonington, Connecticut, researched pertinent data, summarized and evaluated technical information and prepared the final report.

CAPE COD EASTERLY SHORE
BEACH EROSION CONTROL STUDY

VOLUME III
RECONNAISSANCE REPORTS

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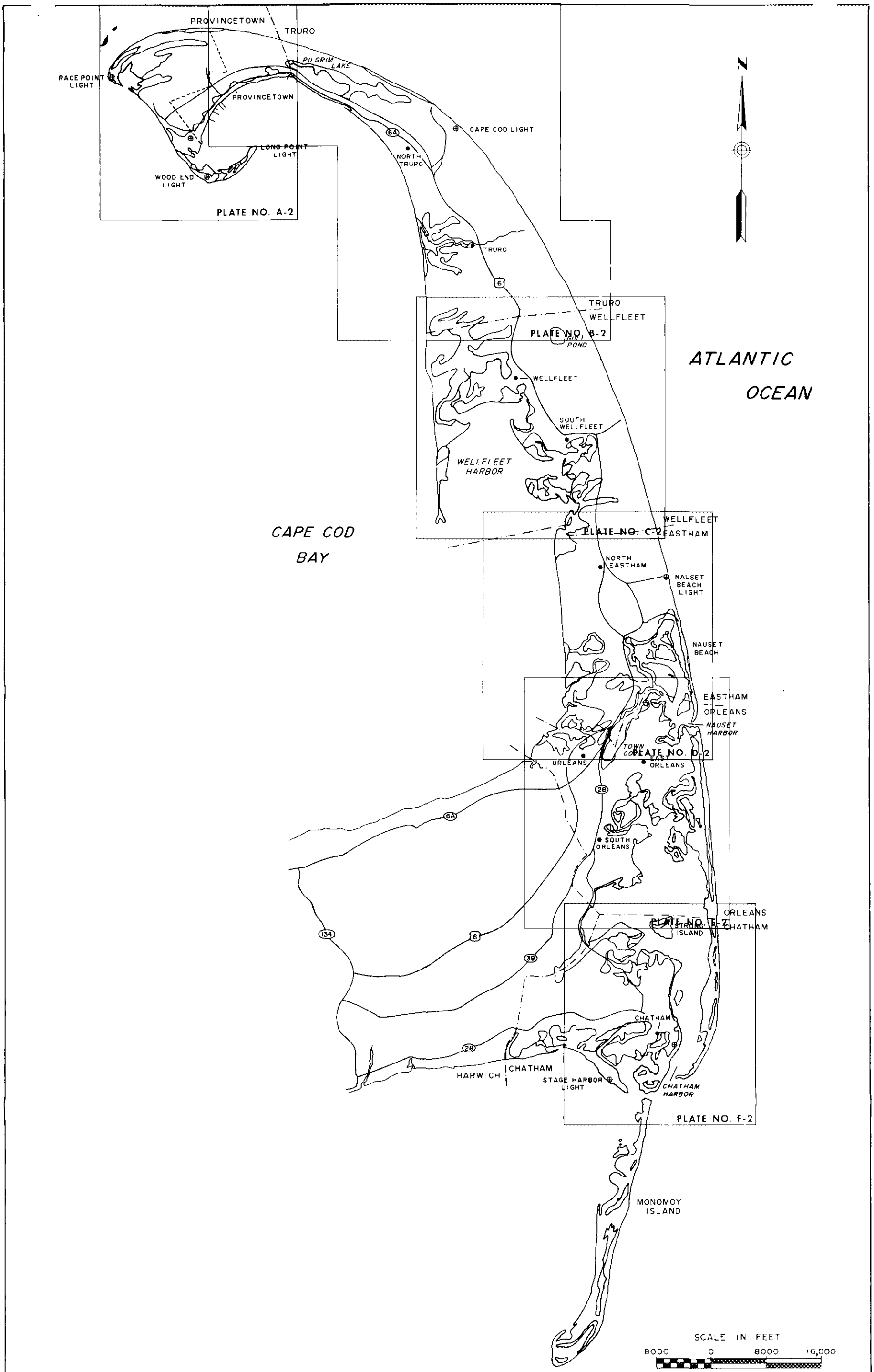

TOWN LOCATION MAPS

TRURO

BEACH EROSION CONTROL STUDY

CAPE COD EASTERLY SHORES

SECTION A

PROVINCETOWN

Photo 1 . August 1977. A typical hot summers day scene on Herring Cove Beach, Provincetown.

Photo 2 . November 1977. An hour before high tide just south of the bathhouse looking south on Herring Cove Beach, Provincetown.

Photo 3 . 1935. An aerial view of Race Point Beach.

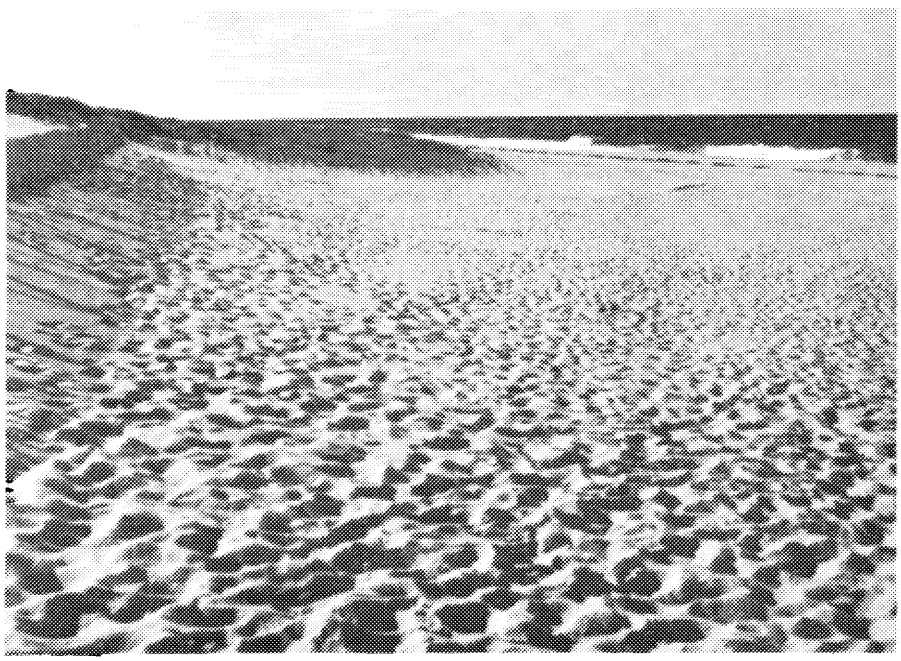

Photo 4 . November 1977. Looking southwest on Race Point Beach, Provincetown on a quiet fall day.

PROVINCETOWN

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PLATES

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PROVINCETOWN

GENERAL

Provincetown (Figure 1) is located at the northern terminus of Cape Cod (Barnstable County), Massachusetts, 112 miles by road from Boston. A study in contrasts, Provincetown consists of a densely populated commercial center situated along Provincetown Harbor and a large, open area (undeveloped except for the airport) that is part of the Cape Cod National Seashore. Tourists are drawn to Provincetown by the excellent beaches, the town's reputation as an artist's colony, the historical significance of the area and the availability of recreational facilities.

Provincetown includes Long Point, a long, sandy spit bent protectively around Provincetown Harbor. Race Point to the north is the site of Race Point Light; Race Point Coast Guard Station is northeast of Race Point. In 1978, Old Harbor Life Saving Station (originally located in Chatham) was placed on the dunes at Race Point Beach where it will serve as a life saving museum. Lighthouses at Long Point, Wood End and Race Point guide mariners into Provincetown Harbor. The harbor is the homeport for the local commercial fishing fleet; ferry service to Boston is also available.

LOCATION AND DESCRIPTION OF BEACHES

Provincetown possesses many sandy beaches: Long Point, Wood End, Herring Cove Beach, Race Point Beach and the north coast of Provincetown from Race Point Beach to the Truro town line are described below.

Long Point

Location - End of hook that makes up Provincetown.

Shore Length - Approximately 1.1 miles.

Ownership - Federal; United States Coast Guard.

Beach Use - Access is by boat or by beach buggy.

Public Facilities - None.

Beach Width - Spit is approximately 500 feet wide.

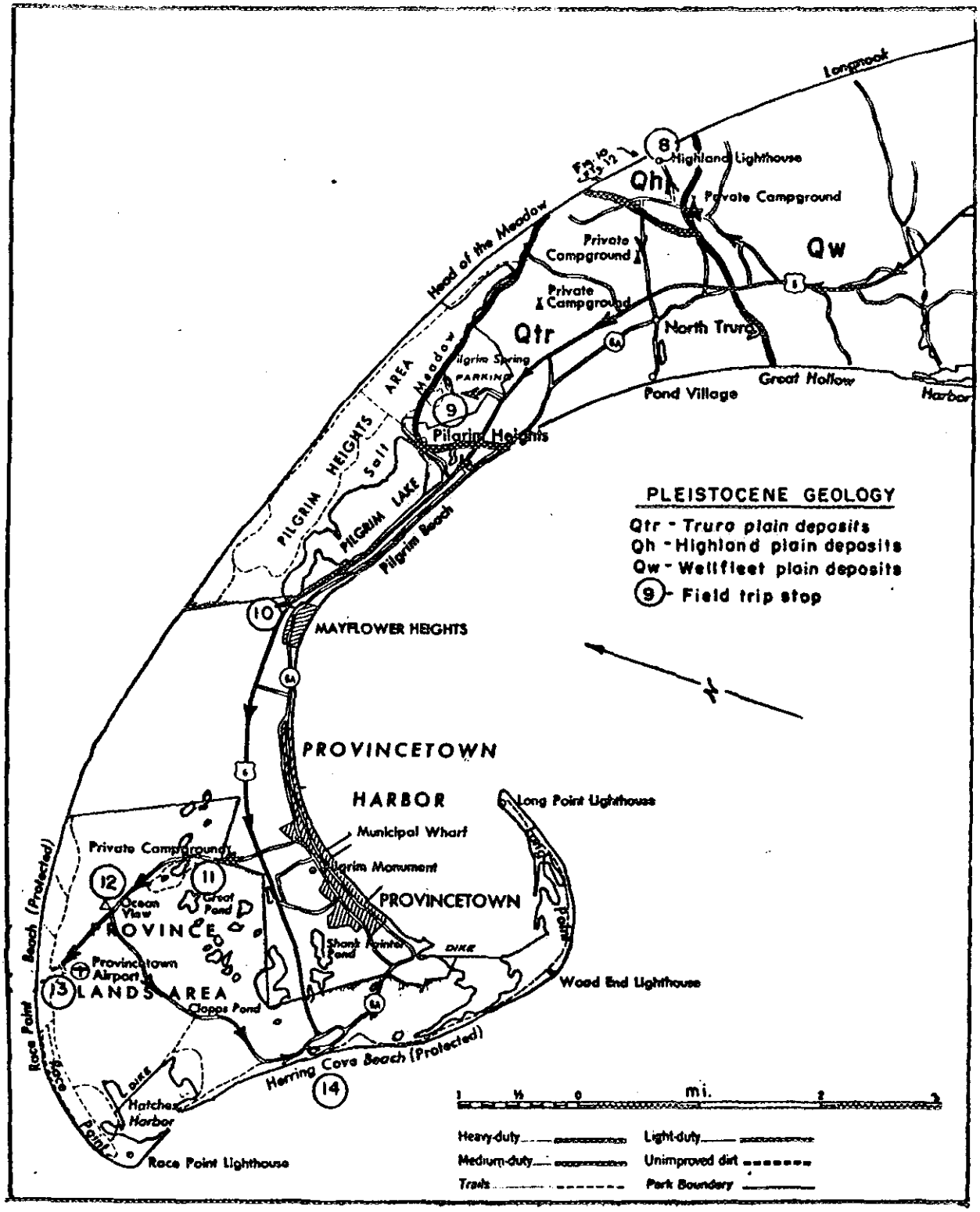


Figure 1. Provincetown, Massachusetts (after Fisher, 1972)

Composition of Shore - Low-lying sand spit with dunes barely reaching several feet above sea level. There are no trees but a scattering of brush is sufficient to hold the sand. Although the spit is frequently overtopped under storm conditions, it is protected from the open ocean by the rest of Cape Cod and is a relatively stable area in terms of erosion and accretion. Continual minor changes counteract each other leaving Long Point with a relatively stable appearance.

Protective Structures - None.

Shore Structures - Long Point Lighthouse is on the extreme end of hook; the light is 36 feet above sea level. First illuminated in 1827, the light is still in operation.

Character of Development - No development.

Wood End

Location - 1.5 miles due south of Telegraph Hill, Provincetown, on the sandy spit extending to Long Point.

Shore Length - Approximately 0.8 miles.

Ownership - Federal; United States Coast Guard.

Beach Use - Access is by boat or by beach buggy.

Public Facilities - None.

Beach Width - In April 1978, the beach was widest at the eastern end (about 150 feet) and narrowest (about 40 feet) where the breach occurred at the western end.

Composition of Shore - Low-lying sand spit with dunes reaching a maximum elevation of approximately 12 feet above mean sea level.

Protective Structures - None. The area is naturally sheltered from most storms; however, overtopping of the spit is not uncommon.

Shore Structures - Wood End Lighthouse was built in 1827.

Character of Development - No development other than the Coast Guard facility.

Herring Cove Beach

Location - At the end of Route 6 on the western coast of Provincetown facing Cape Cod Bay between Wood End and Hatches Harbor (Figure 2).

Shore Length - Shoreline, 4.3 miles; Herring Cove Beach, 1 mile.

Ownership - National Park Service.

Beach Use - Swimming.

Public Facilities - Parking area, large bathhouse; 1500 feet of beach is under lifeguard supervision during the summer.

Beach Width - 75 to 90 feet.

Composition of Shore - Coarse-grained sand with discoid pebbles and cobbles up to several inches in diameter. The beach often lacks a foreshore, berm and backshore and is often a series of steps as is common on shingle beaches farther north along the New England coast (Fisher, 1972). The backshore area consists of sand dunes covered with dune grass and crisscrossed by paths as a result of beach users taking the shortest possible route from the parking area to the beach.

Protective Structures - Asphalt seawall and four stone groins located in front of the bathhouse. The asphalt seawall is crumbling at its southern extremity.

Shore Structures - Wooden stairs leading from the top of the asphalt seawall to the beach.

Character of Development - There is no further development on Herring Cove Beach.

Race Point Beach

Location - Between Hatches Harbor and the eastern boundary of Province Land State Reservation (Figure 3).

Shore Length - 3.8 miles.

Ownership - National Park Service.

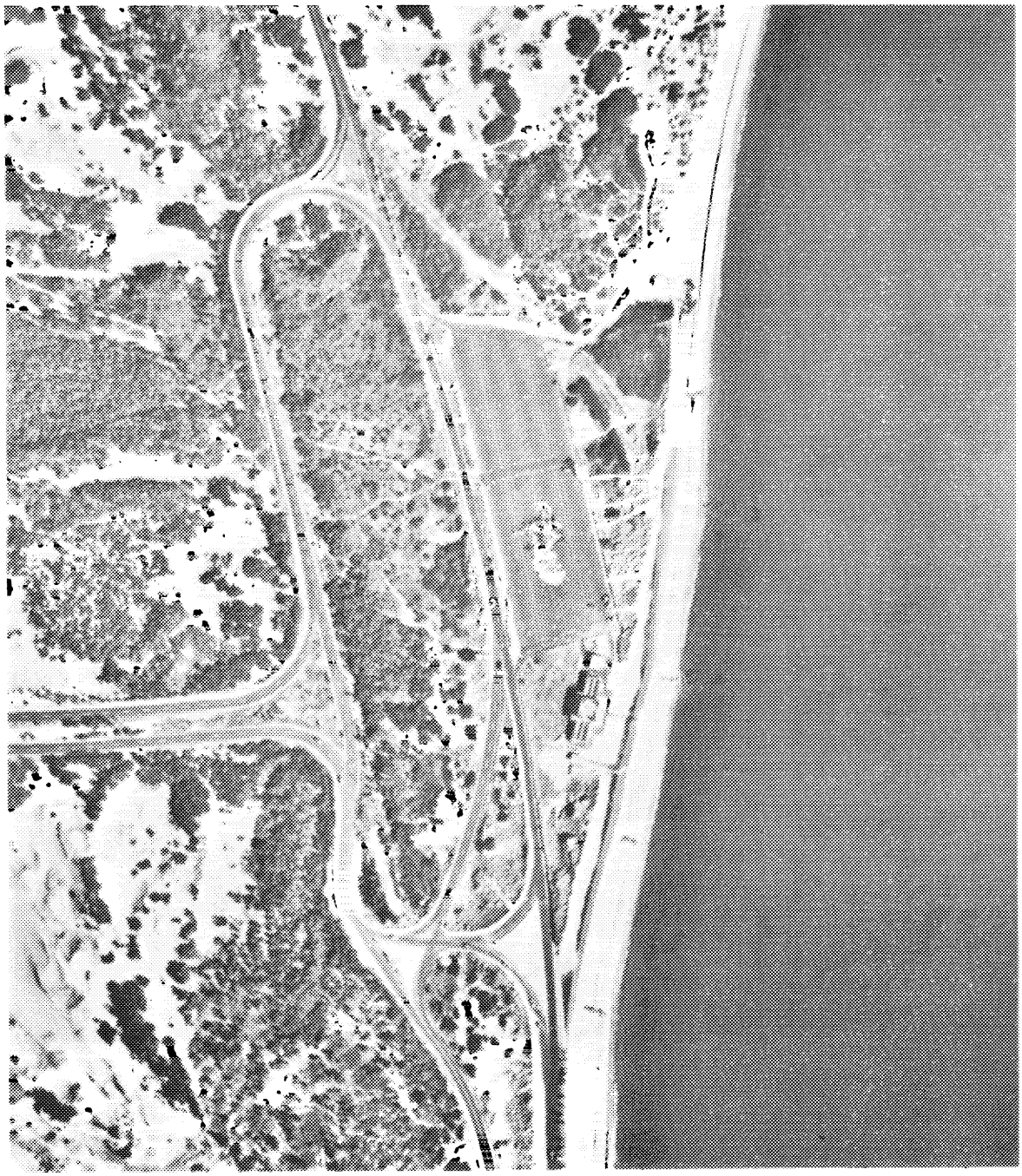


Figure 2. Aerial photograph of Herring Cove Beach, Provincetown, Massachusetts, April 1978

Figure 3. Aerial photograph of Race Point Beach, Provincetown, Massachusetts, April 1978

Beach Use - Swimming and beach buggies.

Public Facilities - Large parking area, public restrooms and lifeguard supervision during summer at an area approximately 1/4 mile north of Provincetown Airport.

Beach Width - 100 to 200 feet. Usually exhibits "abrupt day-to-day changes" (Zeigler and Tuttle, 1961).

Composition of Shore - Coarse-grained sand. A wide, low-lying beach backed by 10- to 15-foot high, grass-covered dunes. In the area of Race Point, large quantities of sand are deposited annually, but the shoreline changes only slightly because the sand deposited on the beach is later blown inland. Peaked Hill Bar, a fairly permanent longshore bar, is about 2000 feet offshore from Race Point Beach. The bar begins offshore from Highland Beach and parallels the shore until it makes a sharp turn to the south at Race Point. At this point Peaked Hill Bar also turns but gradually merges into the shoreline (Fisher, 1972). The coast at Race Point is very treacherous due to the high velocity of tidal currents.

Protective Structures - None.

Shore Structures - Race Point Lighthouse at the westernmost tip of Provincetown was originally constructed in 1816. The lighthouse is owned and operated by the U.S. Coast Guard and is currently unmanned.

Race Point Coast Guard Station is located approximately 1/4 mile north of Provincetown Airport on the northermost part of Cape Cod. A large parking area and public restrooms are adjacent to the station.

Old Harbor Live Saving Station (formerly located at Chatham) has been placed on the bluff at Race Point Beach where it will be used as a life saving museum.

Character of Development - The land surrounding Race Point is desolate and unoccupied with views of open ocean and barren dunes as far as the eye can see. Race Point Coast Guard Station adjoins Provincetown Airport.

Provincetown Coast from Race Point Beach to

Truro Town Line

Location - Between the eastern boundary of Province Land State Reservation and the western boundary of Pilgrim Heights Area (Figure 4).

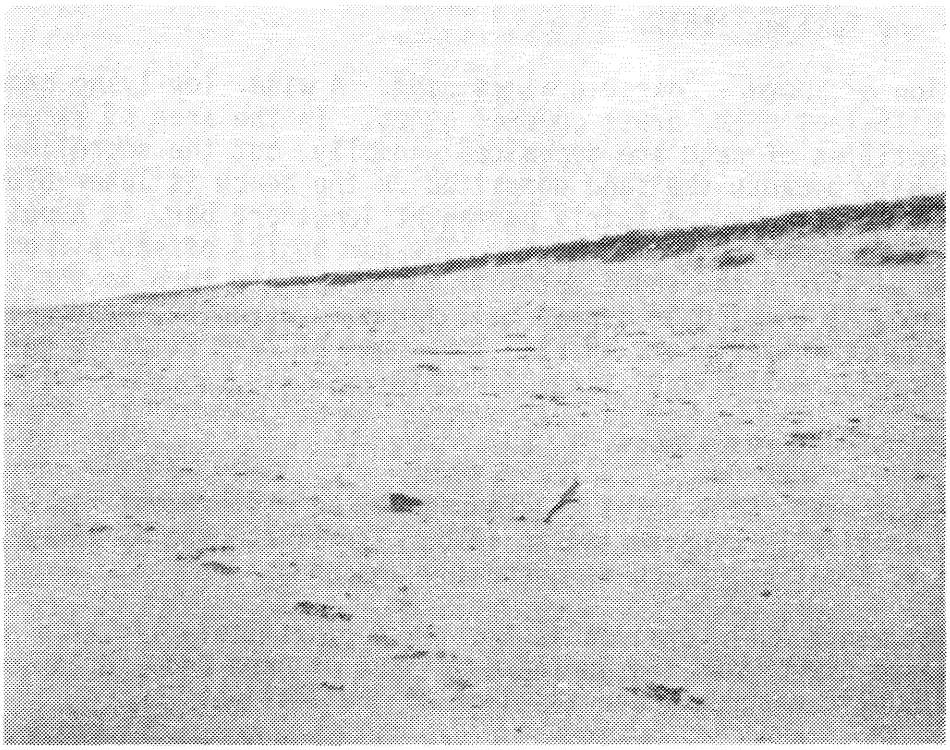


Figure 4. Provincetown shore east of Race Point, April 1977

Shore Length - 2.0 miles.

Ownership - National Park Service.

Beach Use - Swimming and beach buggies.

Public Facilities - None.

Beach Width - 100 to 200 feet.

Composition of Shore - Coarse sandy beach backed by 20- to 30-foot high, grass-covered sandy dunes.

Protective Structures - None.

Shore Structures - Occasional seasonal cottages at the edge of the dunes.

Character of Development - This remote beach is reached by a dirt road nearly 1/2 mile inland from the beach.

STATEMENT OF THE PROBLEM

Problems at Provincetown associated with the movement of sand include shoaling of the harbor; erosion near Long Point and Wood End and at Herring Cove Beach; inland movement of sand deposited at Race Point Beach; and migrating dunes in the Provincelands. Provincetown Harbor is not included in the study area and will not be discussed.

Long Point is frequently overtopped by storm waves and experiences both erosion and accretion. The long-term appearance, however, has been relatively stable. The beach is accessible by beach buggy, and tracks are visible where off-the-road vehicles (ORVs) have strayed from the established tracks.

Wood End, which also experiences overtopping during storms, was breached during the winter of 1977-78. The outer shore is eroding and the inner shore is accreting as material is carried over the spit. Because sand washing across the spit was shoaling Provincetown Harbor, the U.S. Army Corps of Engineers constructed a dike from Provincetown to Wood End in 1914. A large marsh is located in the lee of Wood End. The February 1978 storm opened a section of the outer shore in the vicinity of Wood End Bar. This opening could cause damage to the federal dike located behind the breach and this could have an impact on the harbor.

Herring Cove Beach has been eroding in recent years. Four groins and a seawall have been placed on the beach, but the four groins are in disrepair and offer little if any erosion protection. The seawall protects the backshore but may be intensifying the problem on the beach in front of the

seawall. Formation of the gully in front of the seawall may be an initial step in the eventual undermining of the seawall. If the beach continue to erode, attempting to "hold the line" may involve a substantial beach nourishment project, which is contrary to the present National Park Service policy.

Beach buggies enter Herring Cove Beach at the southern end of the beach parking lot. The access route brings the beach buggies into a large depression at the southern end of the seawall. Numerous tracks are visible in the vegetation near the access route. All routes other than the designated one should be fenced off to preserve the vegetation in this area. Paths are also visible where pedestrians have crossed the dunes to reach the beach from the parking lot. Boardwalks should be provided on heavily travelled paths. Furthermore, beach-goers and ORV drivers need to be alerted to the damage that their actions cause.

Hatches Harbor receives large amounts of sand blown inland from Provincetown's northern coast. Hatches Harbor is a popular area for ORVs, but unfortunately some ORVs have been driven through the tidal flats and marshes.

Access to Race Point Beach is controlled in the area near the parking lot. East and west of the beach, however, numerous paths are visible where ORVs and pedestrians have travelled through the vegetation to reach the beach. At the beach itself, stairs could be provided to prevent sand from being carried down the bluff face as pedestrians make their way down the access routes to the beach.

ORVs gain access to the jeep trail near Race Point Beach. Although a trail is established, some drivers stray from the designated trail. Many tracks are evident both east and west of the beach. Damage to vegetation is particularly evident where vehicles have crossed from the jeep trail to the beach, driving through blowouts and down the face of the bluff. Because it is not feasible to police this activity sufficiently, educational programs are needed to encourage drivers to stay on established trails.

On the beach itself, vehicles and pedestrians must be kept away from tern colonies which nest on the beach, and walking or driving on the bluff face must be prohibited.

Access to the Old Harbor Life Saving Station should be carefully planned to minimize the impact of the large number of visitors. Boardwalks should be provided in any area where heavy pedestrian traffic is anticipated, and vegetated areas should be fenced off. Any vegetation disturbed during the construction process should be replanted.

Sand deposited on Provincetown's northern shore and subsequently carried inland forms dunes in the Provincelands area. If bare, the dunes will migrate in the direction of the wind. Windblown sand poses a hazard to motorists when it accumulates on the highway or sand blasts windshields during storms (Fisher, 1972).

SHORE PROCESSES

The wave refraction analysis discussed in Volume II of the Cape Cod Easterly Shores Study was prepared for each of the towns on Cape Cod's outer shores. Good agreement was found between erosion rates predicted by the wave refraction analysis and erosion rates measured by Zeigler and his associates (1964a) for the coastline from the Highlands of Truro to Nauset Light Beach, Eastham. The area south of Nauset Light Beach consists primarily of migrating barrier beaches; erosion rates in these areas are difficult to predict with any accuracy. The area north of the Highlands includes the northern Provincetown coast which has been accreting and the area from the Race Point to Long Point, including the Long Point spit. Projections in these areas are subject to error.

For the consideration of shore processes, the Provincetown coastline is divided into two parts - the western shore from Long Point to Race Point and the northern shore from Race Point to the Provincetown-Truro town line. These areas are discussed separately below.

Western Shore of Provincetown - Long Point to Race Point

Longshore transport along Provincetown's western coast (Figure 5) is predominately southeast from Race Point to Wood End, then northeast from Wood End to Long Point (Strahler, 1966). The wave refraction analysis (Cornillon et al, 1976) predicts that erosion at rates up to 2 feet per year will predominate along the coast from south of Herring Cove Beach to Hatches Harbor (Figure 6). Projected erosion rates in this area, however, are probably less accurate than rates projected for scarp areas of the outer coast.

PROVINCETOWN

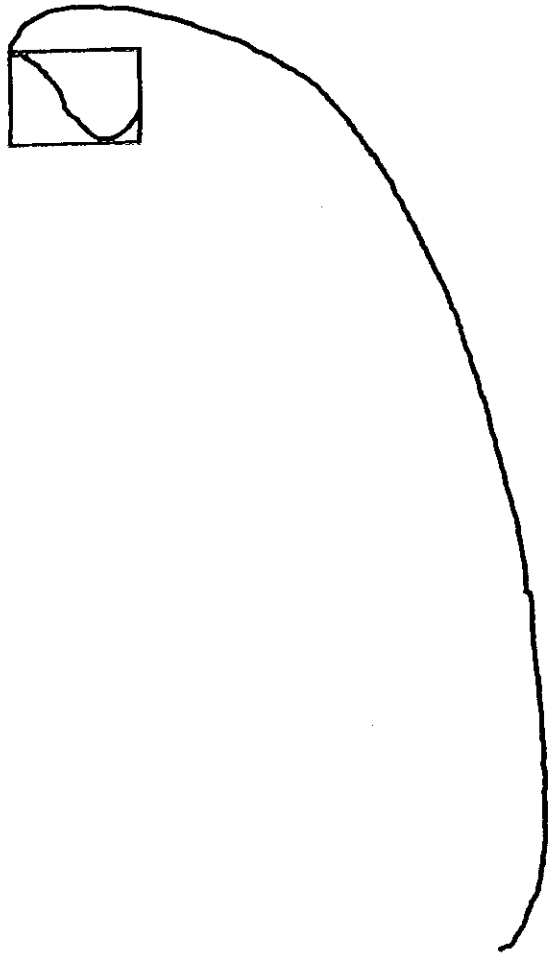


Figure 5. Western coast of Provincetown, Massachusetts, Long Point to Race Point, showing location of area in Figure 6

PROVINCETOWN

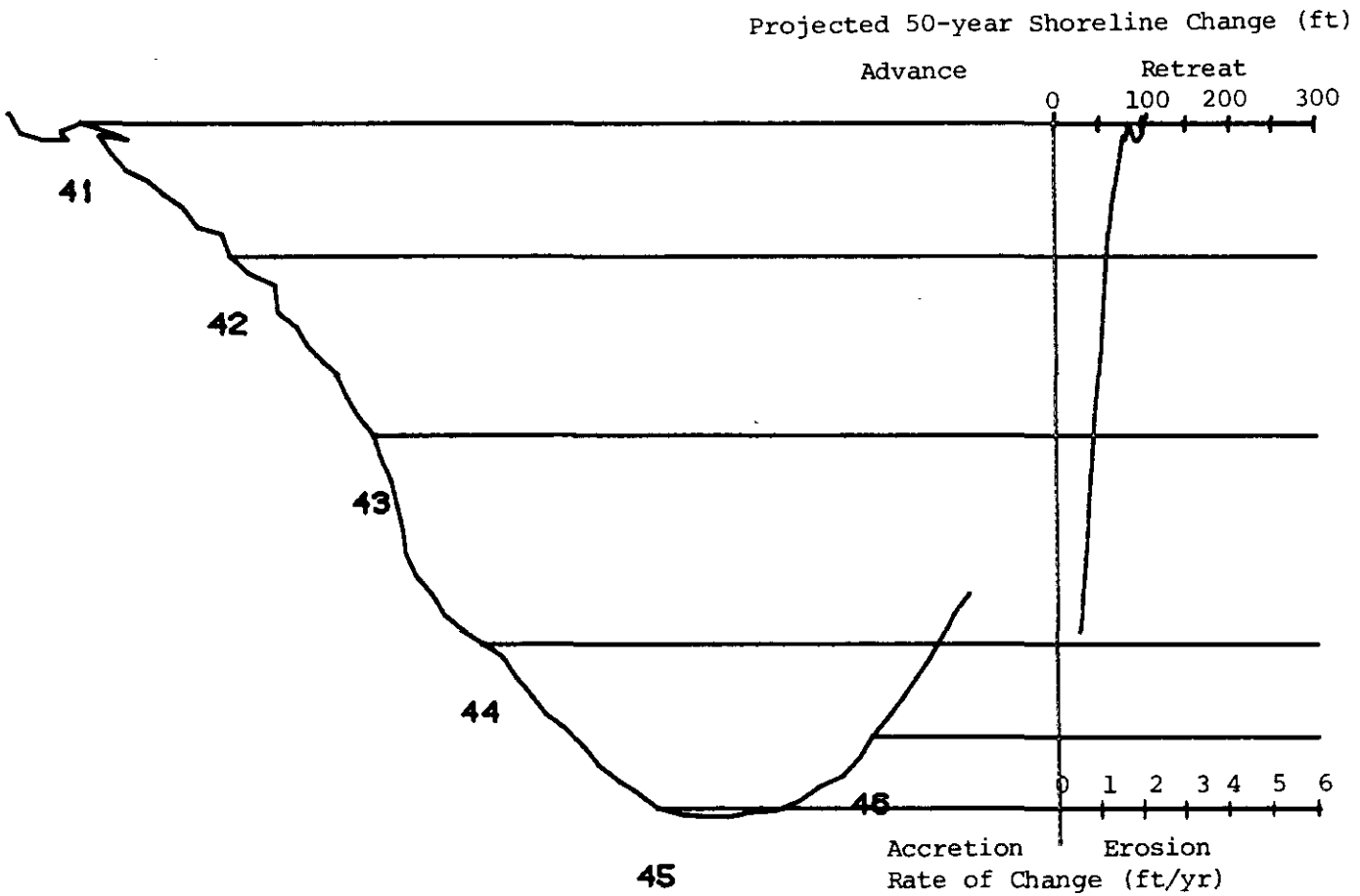


Figure 6. Projected erosion/accretion rates and shoreline changes for the western coast of Provincetown, Massachusetts

Northern Shore of Provincetown -Race Point to Truro

Along Provincetown's northern coast (Figure 7) longshore transport is predominately from the Truro town line to Race Point. The wave refraction analysis (Cornillon et al, 1976) predicts accretion for the easternmost part of this coast and erosion near Race Point (Figure 8). The location where the shoreline process changes from accretion to erosion (a fulcrum point) was identified between the 36-mile mark and the 37-mile mark. The fulcrum point predicted by the wave refraction analysis is probably located to the east of the actual fulcrum point, because the area between Race Point and the predicted point is not undergoing the predicted erosion. Another fulcrum point is located near Race Point where the shoreline process changes from the accretion prevalent on the northern coast to the erosion typical of the western Provincetown shore.

METHODS OF CORRECTING THE PROBLEM

Because the problems concerning the shoreline vary for different sections of Provincetown's coast, the areas will be discussed separately.

Erosion of Provincetown's coast from Long Point to Herring Cove is expected to continue, but the Coast Guard Lighthouses are the only substantial structures involved so that impact of the erosion should be minimal. Because the vegetation on the Wood End to Long Point spit keeps sand from blowing into the harbor, ORVs should be alerted to the damage caused by leaving established trails and driving through the grass and brush. Aerial photographs taken during spring 1978 show tracks through the vegetation and in the marsh behind Wood End. No vehicles should be permitted in the marsh area because the marsh shelters the community least tolerant of ORV impact (Godfrey, 1978).

At Herring Cove Beach several methods have been tried in an attempt to slow the erosion. Four stone groins are presently in disrepair and probably ineffective. The asphalt seawall between the bathhouse and beach is crumbling at its southern end, and during the spring of 1978 a gully was visible at the foot of the seawall. Waves from severe winter storms most probably created the gully when they broke against the seawall.

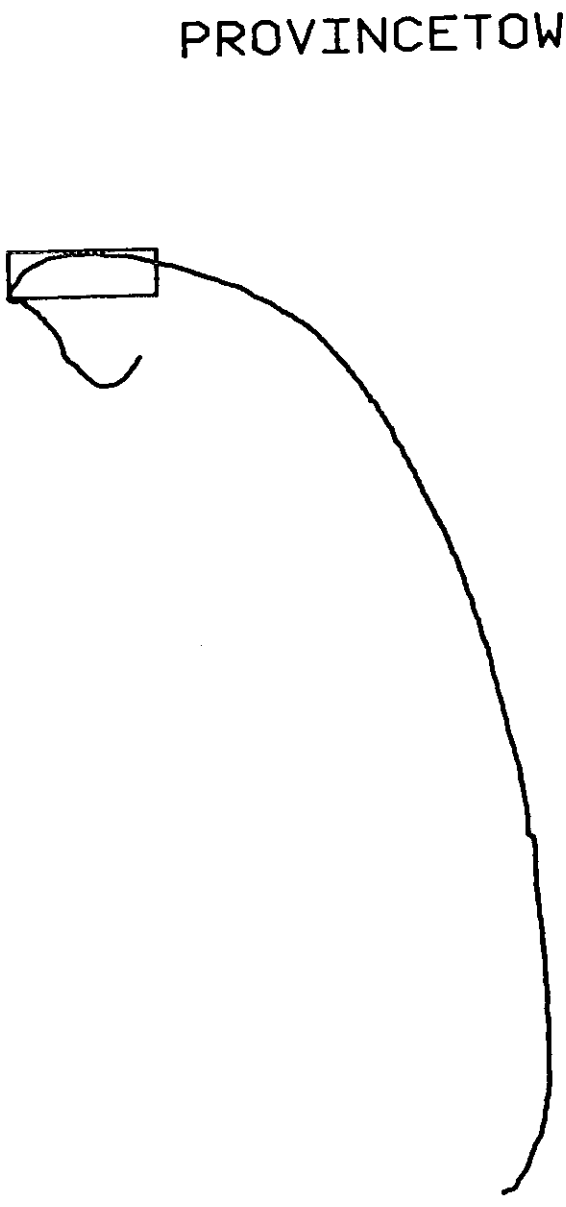


Figure 7. Northern coast of Provincetown, Massachusetts, Race Point to Truro, showing location of area in Figure 8

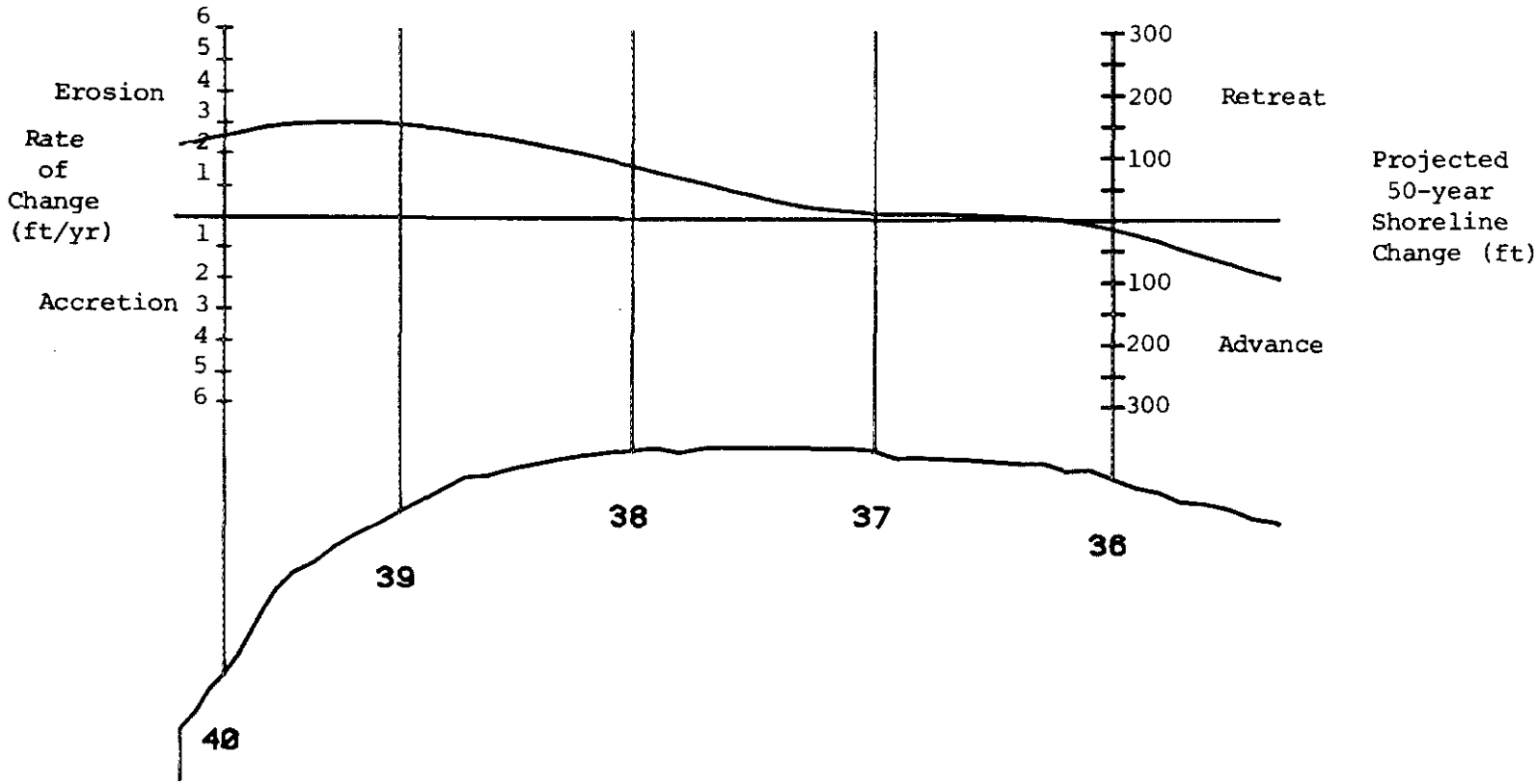


Figure 8. Projected erosion/accretion rates and shoreline changes for the northern coast of Provincetown, Massachusetts

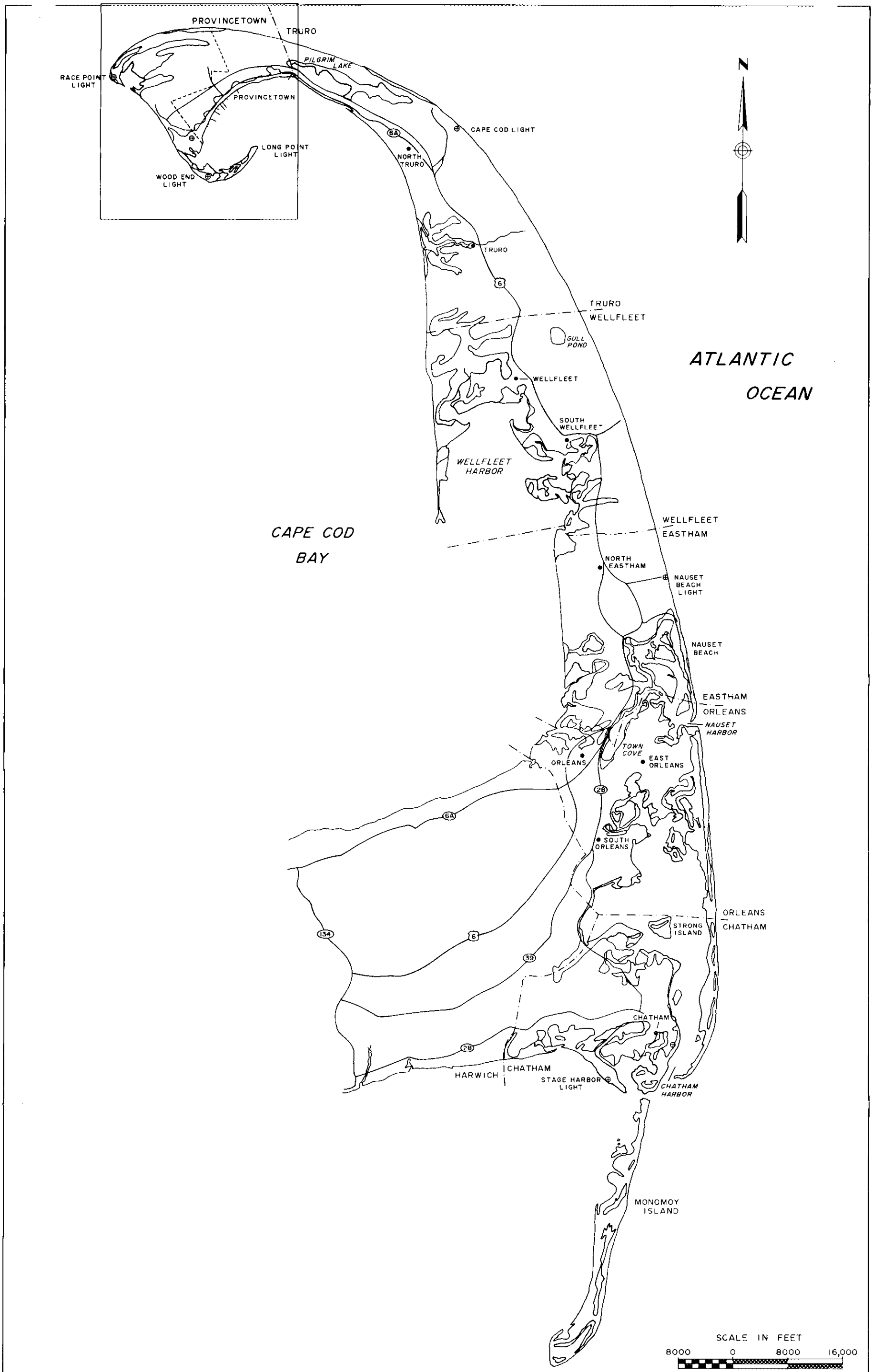
Access from the parking lot to the beach at Herring Cove is provided by several paths to the seawall (and by stairs down the face of the seawall). Other paths, however, have been established through the dunes. These paths should be closed and revegetated, and boardwalks should be provided on heavily travelled paths.

At Hatches Harbor, aerial photographs show additional instances of ORV tracks in the marshes and tidal flats. Driving on any marsh area should be prohibited and popular access points fenced off. Drivers should be alerted to the damage that ORVs cause to the marsh, because patrolling the areas cannot solve the whole problem.

On the northern coast of Provincetown from Race Point to the Truro town line, the principal problems are associated with wind-borne sand. Planting beach grasses can help to reduce the eolian transport of sand because the grasses are able to trap and retain sand. Beach grasses can also be used to create dunes in areas with a sufficient sand supply and to repair dunes that have been damaged (Knutson, 1977).

Existing vegetation and project plantings should be protected from damage by pedestrians and ORVs. Aerial photographs of the Provincelands show tracks through healthy vegetated areas. Crossovers from the jeep trail to the beach, that will not damage the dune face or perpetuate blowout areas, should be designated so that other damaged areas of the dune face, presently used as access to the beach, could be fenced off.

At Race Point Beach, access from the parking lot to the beach is controlled by fencing; boardwalks can be used in heavily travelled areas to reduce the impact on existing vegetation. Numerous paths have been cut through the dunes east of the beach, and educational programs are needed to inform people of the damage that uncontrolled access can cause.

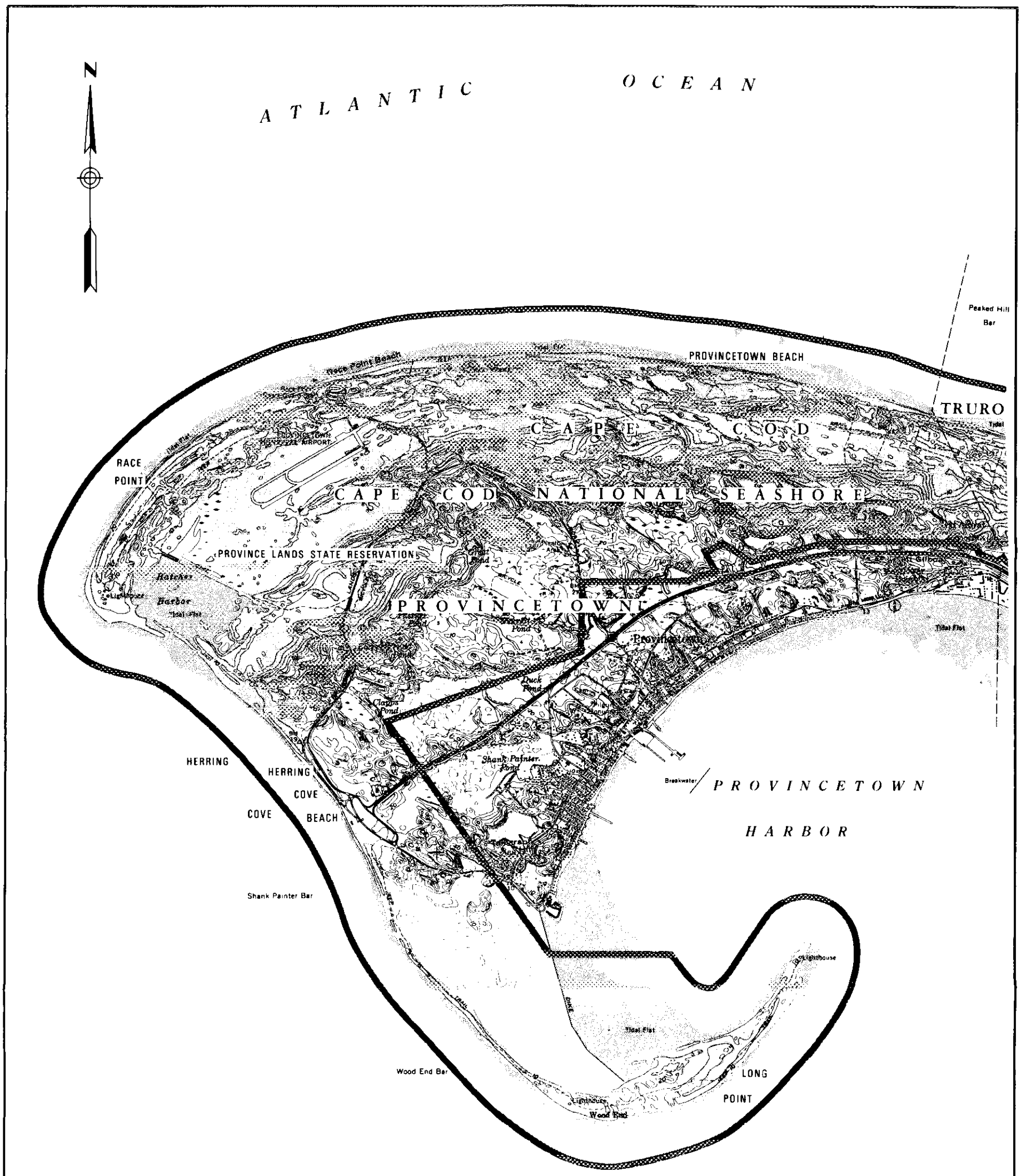


TOWN LOCATION MAP

PROVINCETOWN

BEACH EROSION CONTROL STUDY

CAPE COD EASTERLY SHORES



PROVINCETOWN

BEACH EROSION CONTROL STUDY

CAPE COD EASTERLY SHORES

PLATE A-2

SECTION B

TRURO

Photo 1. April 1977. A view to the northwest from Head of the Meadows Beach, Truro.

Photo 2. April 1977. Looking to the southeast from the same point on Head of the Meadows Beach as in Photo .

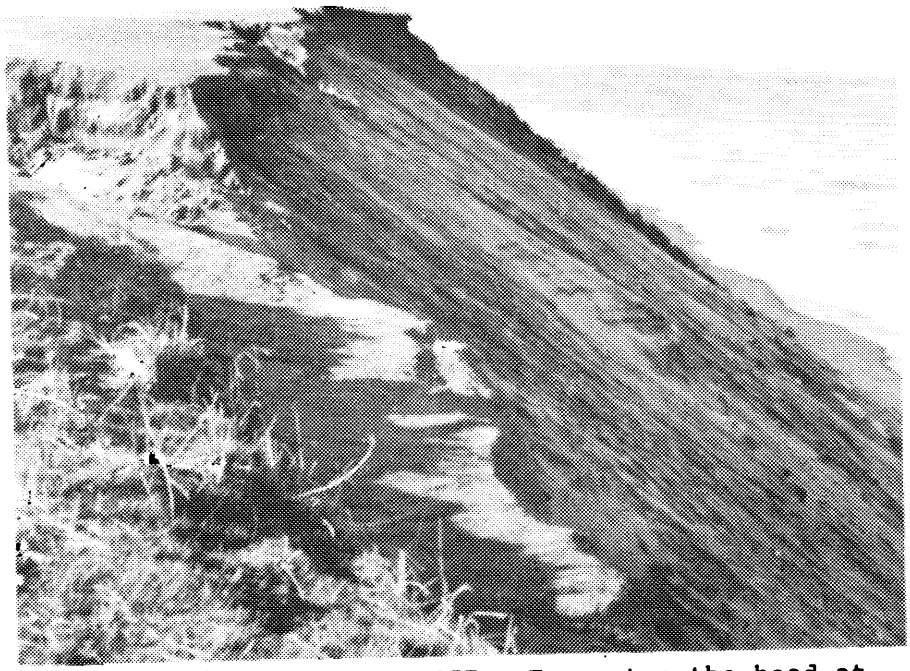


Photo 3. November 1977. From atop the head at Highland Light looking towards the northwest at high tide.

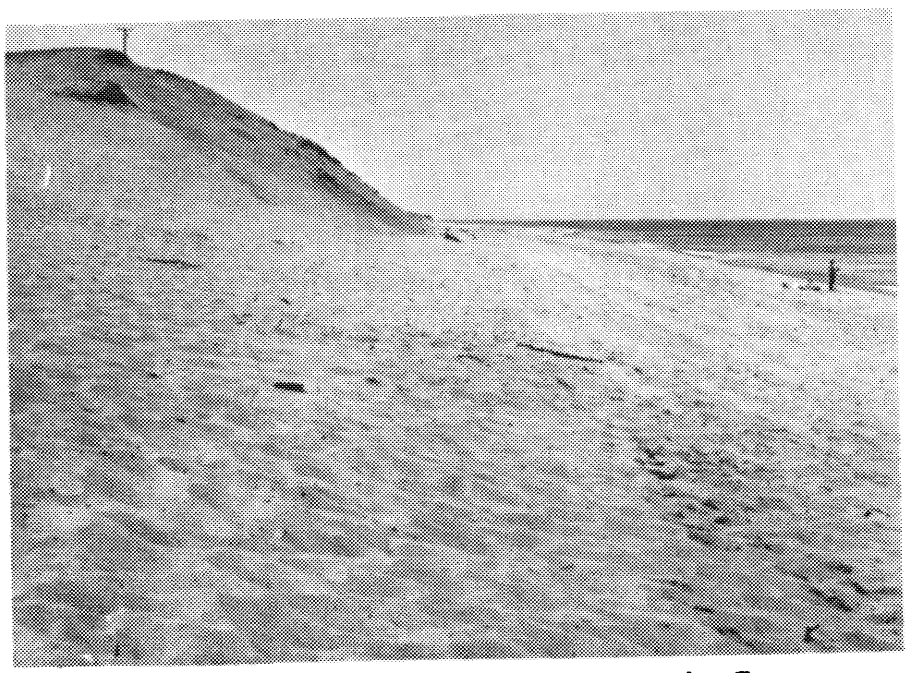


Photo 4. April 1977. Highland Beach, Truro.

Photo 5. August 1977. Highland Beach at low tide on a summer day.

Photo 6. August 1977. Longnook Beach, Truro, spanning out from scarp at low water.

Photo 7. August 1977. Ever expansive beach area again exhibited in this view of Ballston Beach, Truro.

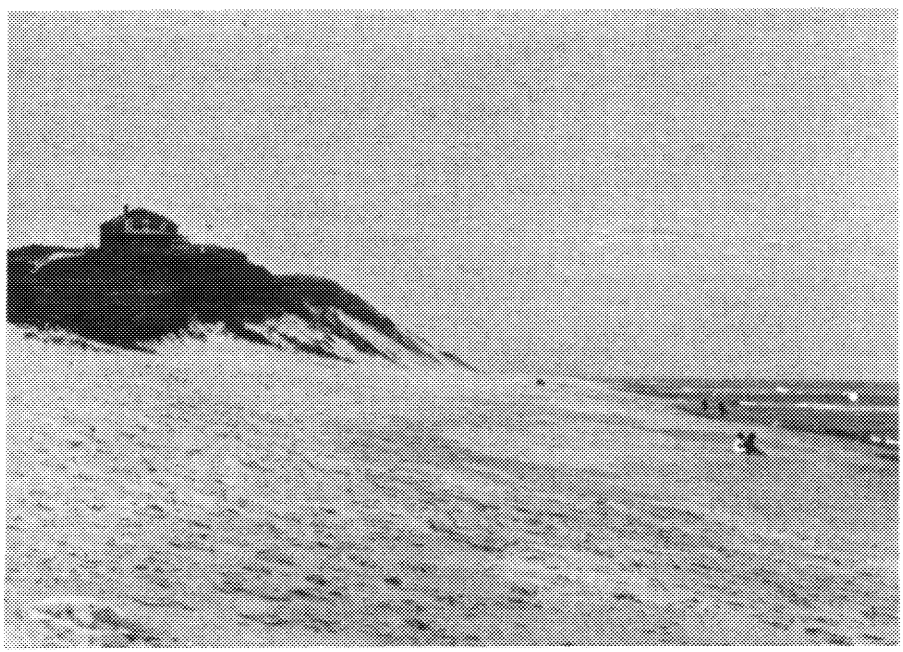


Photo 8. August 1977. A look to the north from Ballston Beach.

TRURO

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TRURO

GENERAL

The town of Truro (Figure 9) is located between Provincetown and Wellfleet. Truro's eastern shore contains many of the landforms of the entire eastern shore of the outer Cape. The shifting dunes of Pilgrim Heights form a barrier between the Atlantic Ocean and Pilgrim Lake and Salt Meadow on the northern third of Truro's shore. The materials to form these dunes were derived from the remaining two-thirds of Truro's outer shore - the high marine scarp being eroded by natural and manmade causes. Thus, Truro will have to address itself to several types of erosion problems - those affecting low dune areas and those involving the continuing retreat of the high scarp.

LOCATION AND DESCRIPTION OF BEACHES

Head of the Meadow Beach

Location - Between the western boundary of Pilgrim Heights Area and Highland Beach (Figure 10).

Shore Length - 4.7 miles.

Ownership - National Park Service.

Beach Use - Swimming.

Public Facilities - Two parking areas, one provided by the National Park Service, the other by the Town of Truro.

Beach Width - 75 to 100 feet.

Composition of Shore - Fine-grained sand. Most of the beach is backed by a 20-foot high dune while the southern 1500 feet of the beach are backed by an 80-foot high sandy scarp; however, in two places northeast of Salt Meadow, the dune has been cut to within 10 feet of mean sea level. The dunes are covered by grass and other low salt-resistant plants, such as bayberry.

Protective Structures - None.

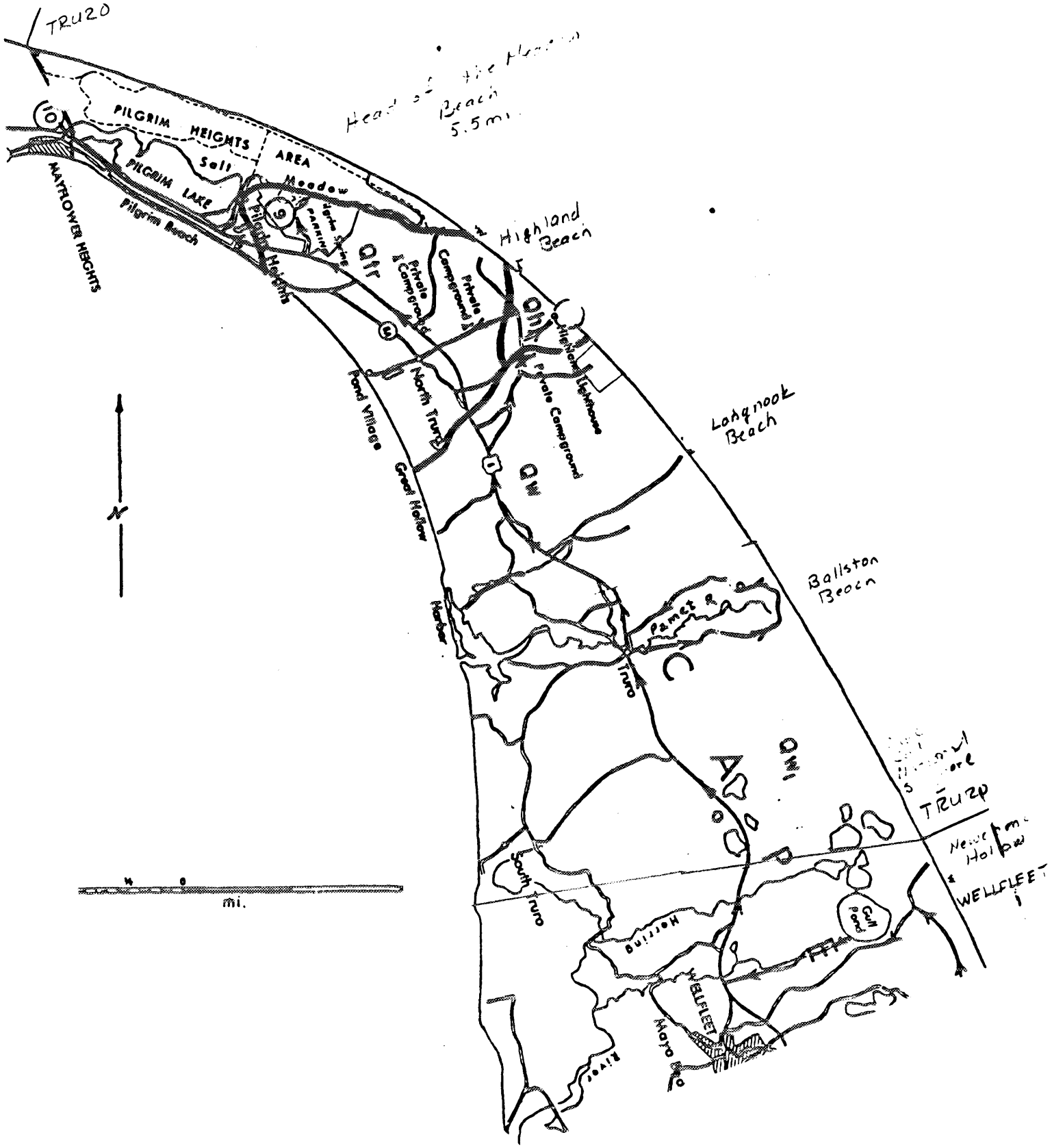


Figure 9. Truro, Massachusetts (after Fisher, 1972)

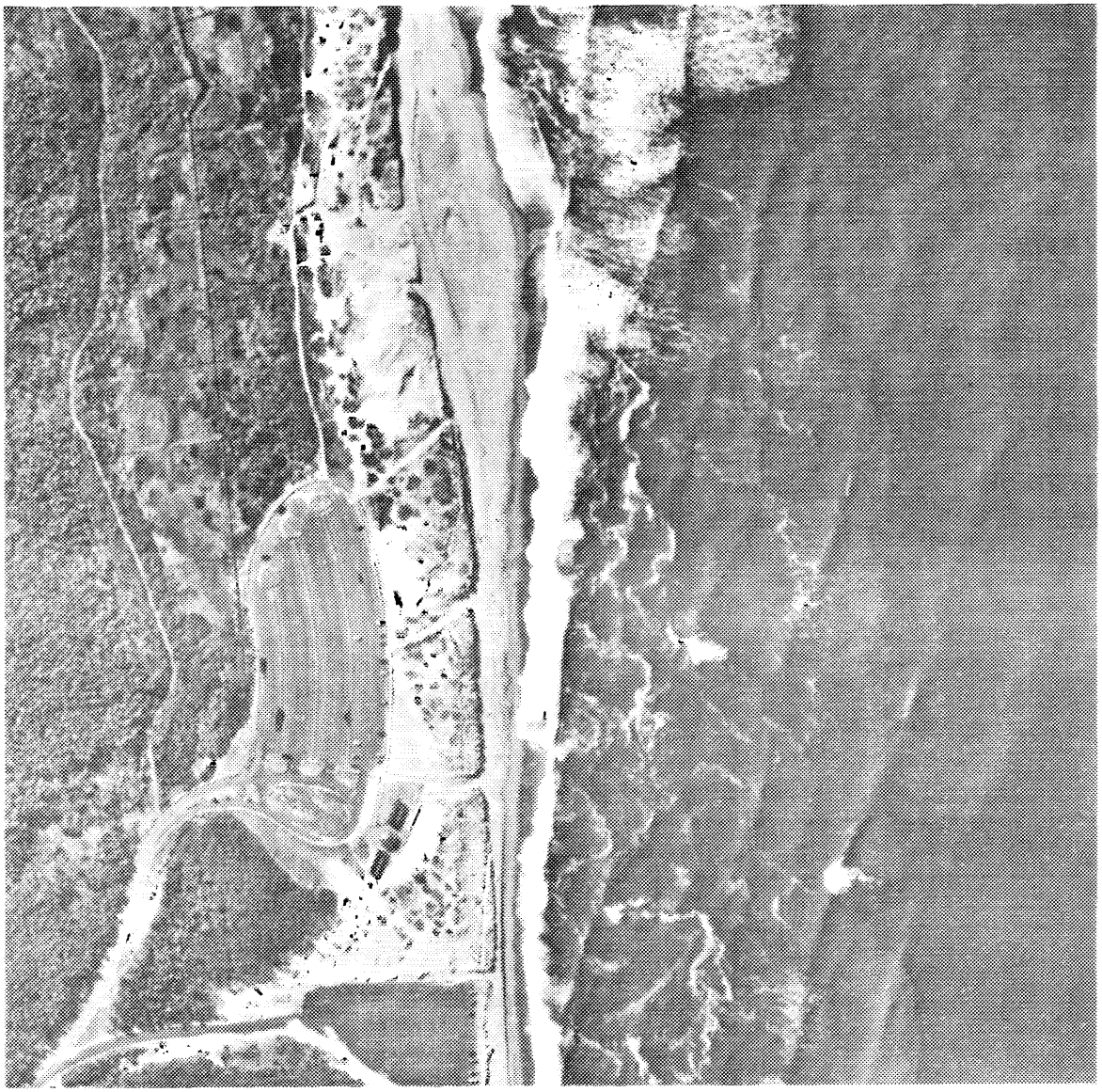


Figure 10. Aerial photograph of Head of the Meadow Beach, Truro, Massachusetts, April 1978

Shore Structures - There are no significant shore structures.

Character of Development - The area has been kept in its natural state with little development.

Cape Cod National Seashore 1

Location - Between Head of the Meadow Beach and the northern boundary of the North Truro Air Force Station; includes Highland Beach (Figure 11).

Shore Length - 1.5 miles.

Ownership - National Park Service.

Beach Use - Swimming.

Public Facilities - Limited parking; lifeguard protection for approximately 500 feet of Highland Beach.

Beach Width - Ranges from 0 to 25 feet in the south to 75 to 100 feet in the north; during the summer the beach is irregularly shaped, varying from 75 to 250 feet in width with considerable development of sand bars 50 to 200 feet offshore.

Composition of Shore - Medium-fine-grained sand. Beach extends to the base of 80- to 120-foot high scarps. At the base of the scarp, 30 to 70 feet of iron-stained, coarse sand to gravel containing pebbles and cobbles is overlain by 0 to 40 feet of gray clay and silty clay, which is then overlain by 15 to 20 feet of yellowish-gray, fine- to medium-grained sand (Fisher, 1972). This material erodes in an irregular manner.

Protective Structures - None.

Shore Structures - Highland or Cape Cod Light, originally constructed in 1797, is still an extremely important navigation aid. The light is manned and operated by the U.S. Coast Guard. A radio tower is located close to it.

Character of Development - The beach is the least developed of all the beaches within the National Seashore. The parking is limited and lifeguard protection is provided for only a small section of the beach.

Erosion problems in the area are aggravated by several factors. Access to the beach is not controlled and as a result, beach users walk up and down the bank to the beach wherever it is convenient. In addition, surface drainage is routed by pipe to outfall over the face of the bank.

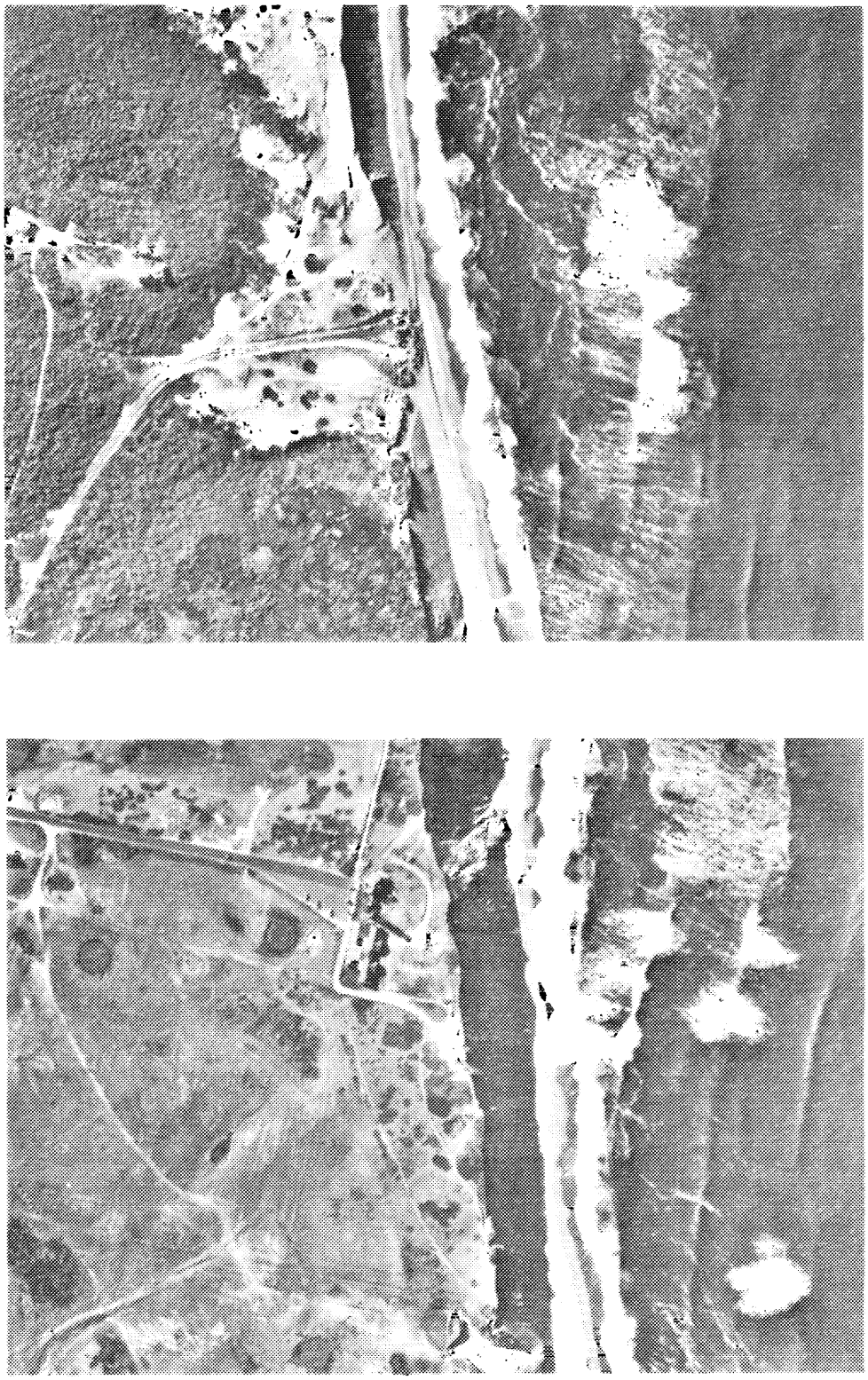


Figure 11. Aerial photographs of Highland Beach (top) and Highland Light Beach (bottom), Truro, Massachusetts, April 1978

Overland flow of runoff from the parking area, the access road, and the surrounding area also causes severe erosion.

Longnook Beach

Location - Between the northern boundary of the North Truro Air Force Station and the Green Hill radio towers (Air Force Station) (Figure 12).

Shore Length - 1.5 miles

Ownership - United States Air Force in front of the Air Force Station; Town of Truro in the south.

Beach Use - Swimming.

Public Facilities - Small parking area.

Beach Width - 75 to 150 feet.

Composition of Shore - Fine-grained sand. Beach is backed by a scarp reaching a height of 158 feet at the radio tower site.

Protective Structures - None.

Shore Structures - North Truro Air Force Station and radio towers on Green Hill. The road to the radio towers comes within 30 feet of the edge of the bluff and may well be threatened by continued erosion. There are a few seasonal homes between the North Truro Air Force Station and the radio towers; two of them are located on the edge of the bluff.

Character of Development - This beach is undeveloped except for a small parking lot.

Ballston Beach

Location - Between the Green Hill radio towers and Pamet Point (Figure 13).

Shore Length - 2.5 miles.

Ownership - Town of Truro.

Beach Use - Swimming.

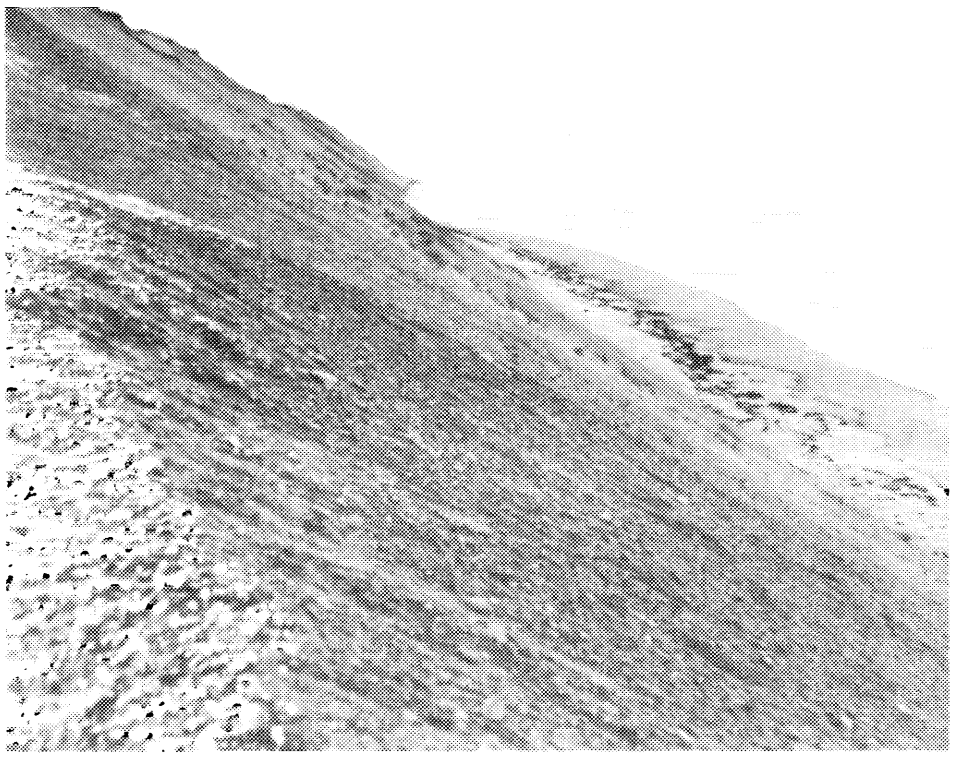


Figure 12. Longnook Beach, Truro, Massachusetts, November 1977

Figure 13. Ballston Beach, Truro, Massachusetts, April 1977

Public Facilities - Parking area.

Beach Width - 75 to 150 feet.

Composition of Shore - Fine sand with gravel at wash line. The 100-foot high scarp behind the beach is deeply notched by the truncated valley of the Pamet River. A wide, sandy beach of varying width and a narrow, grass-covered dune less than 20 feet high are all that separate the Atlantic Ocean from the hanging valley of the Pamet River. The top of the scarp is also notched, producing additional erosion by blowouts.

Protective Structures - None. Grass has been planted on the dune east of Pamet River.

Shore Structures - None.

Character of Development - Several seasonal homes are located on and behind the dunes where North and South Pamet Roads approach the shore.

Cape Cod National Seashore 2

Location - Between Pamet Point and the Truro-Wellfleet town line.

Shore Length - 1.7 miles.

Ownership - Town of Truro.

Beach Use - Swimming and beach buggies.

Public Facilities - Parking area.

Beach Width - 75 to 150 feet.

Composition of Shore - Fine-grained sand with gravel at wash line. The broad beach terminates against a high, 100-foot scarp that is interrupted by several pamets that provide access to the beach. (A pamet is a truncated, westward sloping stream valley that once drained runoff from the retreating glacier to the east of Cape Cod.)

Protective Structures - None.

Shore Structures - Several seasonal cottages on top of 50-foot dunes at south end of beach.

Character of Development - There are a few seasonal cottages at the southern end of the beach just north of the Truro-Wellfleet town line. The rest of the shore and dune area are undeveloped.

STATEMENT OF THE PROBLEM

The effect of severe winter storms has been erosion of the steep scarp behind most of Truro's beaches, and the removal of this material by littoral transport. The scarp is estimated to be retreating at approximately 3 feet per year (Zeigler et al, 1964b). Very few buildings have been located close to the edge of the scarp so there is little immediate danger to existing structures. However, there is a real concern locally for the continuing erosion of the Cape Cod mainland. It is hoped that some way can be found to halt the ocean's advance and the severe erosion caused by winter storms.

At present both of the National Park Service facilities at Head of the Meadow Beach are protected from winter storms by the foredune and broad beach between them and the ocean. The beach in front of the northern end of the parking lot was approximately 20 feet wide in September 1977, but unless this portion of the beach is replenished, winter storms could erode part of the foredune.

Two potential washover areas are located on the dune northeast of Salt Meadow. Both of these depressions in the foredune have elevations of 10 feet or less. These areas have not been washed over recently but they should be kept under observation, protected from traffic and allowed to increase in elevation by natural or artificial dunebuilding processes.

One beach buggy access to the beach is a continuation of High Head Road directly across the parabolic dunes. A sizable depression has already developed where this road crosses the foredune to the beach, and regular traffic and continued wind erosion are contributing to its increasing size. The dune area extends nearly 2,000 feet shoreward from the crest of the foredune to the edge of Salt Meadow so this breach in the foredune may not be critical.

The 150-car parking area at the end of Head of the Meadow Road is the source of several problems. The ocean edge of the parking area is being undermined because it is immediately behind the beach berm. Beach buggy access to the beach is allowed at either side of the parking area causing additional mechanical and eolian erosion. Wind and waves have moved sand to cover nearly 20 feet of the ocean end of the parking area. In normal beach development this sand would be held by vegetation to increase the height of the dune behind the beach. On the parking surface it is a nuisance and is removed, thus interrupting a natural process. Storm runoff from the parking area is conducted to the beach by means of a pipe that extends over the beach about 10 feet and is about 5 feet above the beach. In its outfall area, the pipe has accelerated the undermining of the parking lot.

The Highland Beach portion of the outer Cape has been subject to severe weather conditions with winds over 100 miles per hour common and occasional waves to the top of the 80- to 100-foot scarp. Such weather conditions are in part responsible for the erosion of the shoreline at Highland Beach. However, both the rate and location of erosion here are very unpredictable due to the large clay deposits underlying the upper sand layer. Sometimes an area will not be eroded for years but the adjacent land will lose as much as 50 to 60 feet during a single storm.

A comparison of Zeigler's 1958 or 1959 profile at Highland Beach with Marindin's 1887 or 1889 profile (Zeigler et al, 1964b) illustrates two characteristics of erosion at Highland Beach. First, the base of the scarp eroded 150 feet in 70 years at a rate of 2.1 feet per year. Second, the top of the scarp retreated only 50 feet in the same time at a rate of 0.7 feet per year.

From the southeastern end of Head of the Meadow Beach to the North Truro Air Force Base the shoreline is a series of nearly sinusoidal curves with three areas of broad beaches and four areas where there is no beach and the waves are eroding the base of the scarp. (A portion of this is apparent in Figure 14.) The scarp is currently being eroded north of the Highland Beach parking area, at a point 2,200 feet south of there, in front of Highland Light and opposite the northern boundary of the Air Force Station.

The parking area at Highland Beach is being undermined by erosion of the scarp in front of and to either side of it. The erosion of the front area is accelerated by drainage of surface runoff through a pipe extending over the scarp. A significant gully has formed under the pipe. Access to the beach is uncontrolled with pedestrians leaving the parking area at any convenient place. Every step on the scarp moves sand downward to the beach where longshore currents carry it away. South of the parking area is a beach buggy access that has worn a path into the scarp where it is less steep. North of the parking area is a region that has been scoured by the wind. This wind-scoured area is also one of the regions where the waves are breaking directly against the base of the scarp (Figure 14).

A different problem is seen at Ballston Beach where the low, narrow dune and beach are all that separate the Atlantic Ocean from the freshwater Pamet River valley. Should this dune be permanently breached, salt water would flow into the Pamet River valley making the land to the north an island, but, of more importance, invading a freshwater valley and recharge area. The water supply in the area would be affected, necessitating remedial action. Local interests feel very strongly that this critical barrier beach should be maintained and protected.

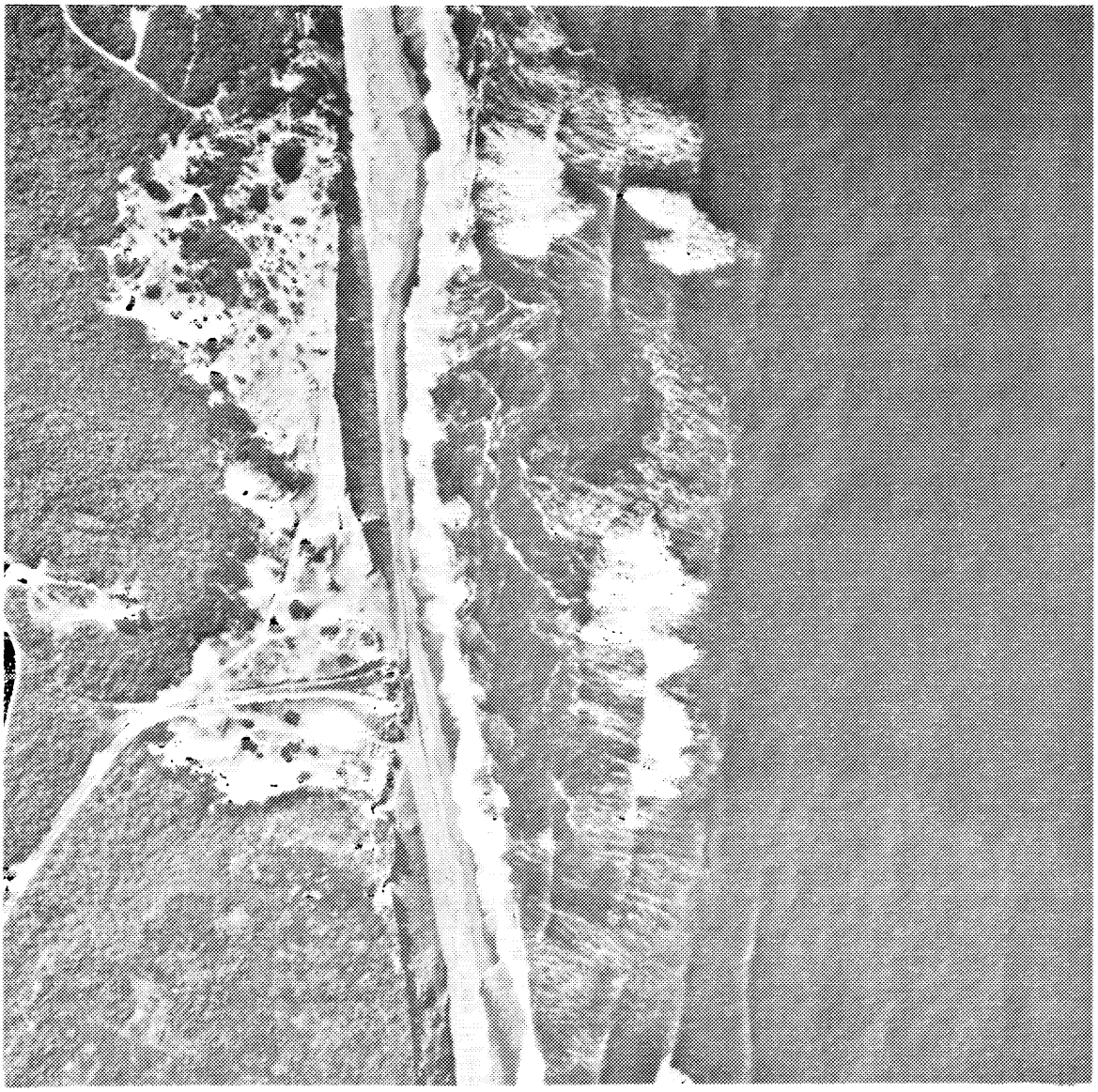


Figure 14. Highland Beach Parking Area, Truro, Massachusetts

SHORE PROCESSES

Longshore sediment transport on the Truro coast (Figure 15) is predominantly to the north along the entire shore (Cornillon et al, 1976). Northerly longshore currents are induced by waves from the east-northeast, east, east-southeast and southeast. Waves from the northwest quadrant can produce southerly longshore currents. When waves approach Truro from the north-northeast and northeast, longshore current is to the north in the northern section of Truro's coast and to the south below Highland Light.

A fulcrum point (location at which the longshore transport attains a maximum or minimum and no net erosion or accretion occurs) for average yearly wave conditions was predicted at the 31-mile mark (near Head of the Meadow Beach). Zeigler and his associates (1964a) found that the shoreline process changed from erosion to accretion at about the 33-mile mark; the predicted fulcrum point at the 31-mile mark agrees well with this observation.

Erosion along the southern part of Truro (south of the 31-mile mark) is predicted to average about 1 to 1.5 feet per year (Figure 16). One or two feet of accretion per year are anticipated north of the fulcrum point.

METHODS OF CORRECTING THE PROBLEM

At Head of the Meadow Beach, erosion in front of the town parking lot is aggravated by uncontrolled vehicular and pedestrian access to the beach and the outfall from storm runoff. Grass planting, controlled access and improved drainage might temporarily slow the erosion, but due to the narrowness of the beach, it may be too late for these remedial measures to have any significant impact.

Several simple improvements could prolong the existence of Highland Beach: (1) controlled beach buggy access to the beach, (2) fences and stairs to protect the scarp from pedestrian traffic, (3) relocation or extension of the drainage pipe and (4) beach grass plantings to help control sand loss and to catch sand in the wind-scoured area.

Pedestrian access to the beach is also a problem at Longnook Beach. Stairs should be provided and beachgoers should be prohibited from walking on the scarp face and dunes at the top of the scarp. Grass planting could be used to stabilize the sandy areas at the top of the scarp.

TRURO

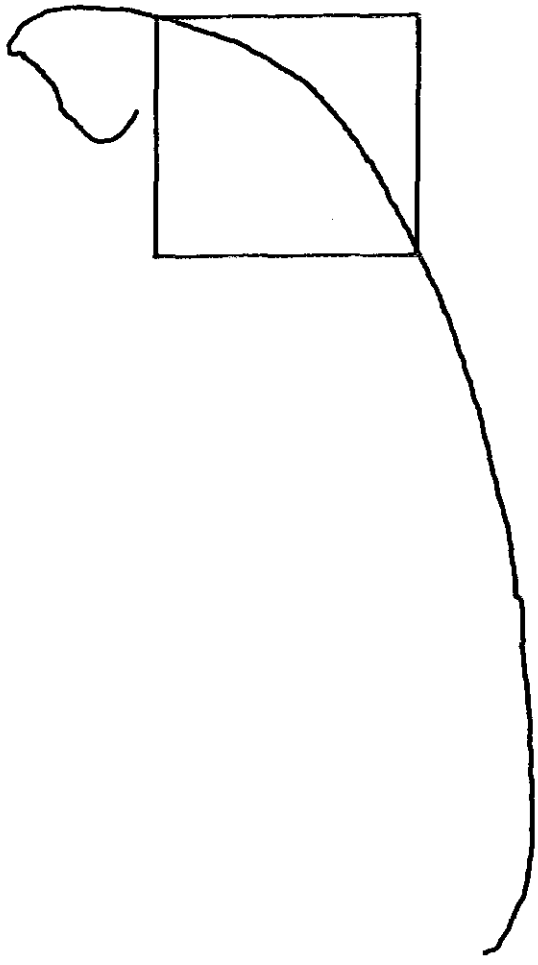


Figure 15. Atlantic coast of Truro, Massachusetts - location of area shown in Figure 16

TRURO

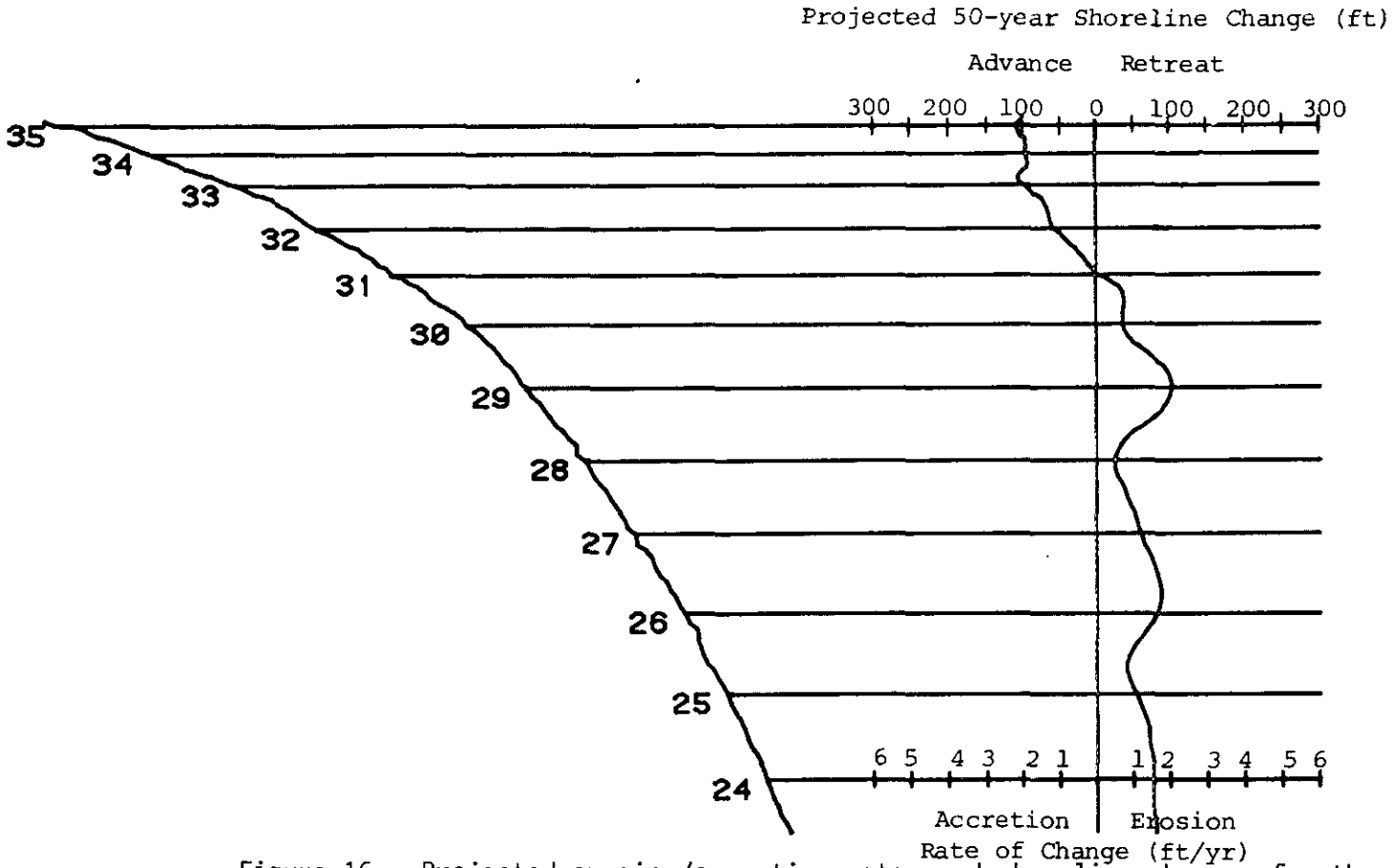


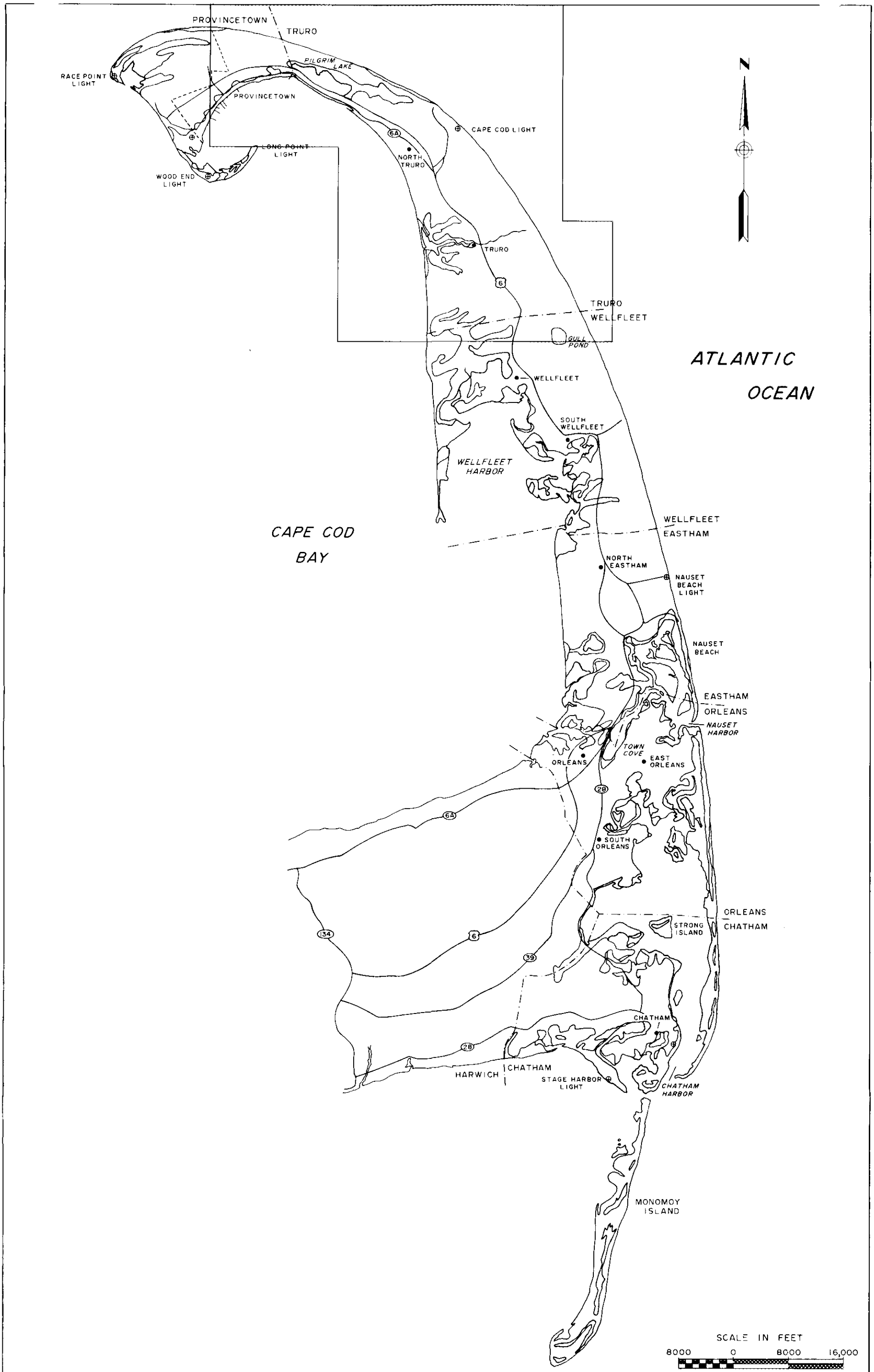
Figure 16. Projected erosion/accretion rates and shoreline changes for the Atlantic coast of Truro, Massachusetts

Erosion at Ballston Beach is a potentially more serious situation because it could allow salt water to enter the Pamet River valley, threatening the ground water of the area.

> In the case of Ballston Beach at the head of Truro's Pamet River, striking evidence of the sea's advance upon the land was given in the winter of 1972 during a severe easterly storm. Waves washed over the dwindling barrier dune onto the paved road connecting North and South Pamet Roads and threatened the fresh waters of Pamet River. . .
>
> But man's unintentional intervention was already too great. The advent of the automobile had led to the stabilization by hard surfacing, and later paving of this road running behind the barrier dune. The shoreline here is naturally receding inland. Left to its normal movement, the dune would have migrated inland, all the while maintaining its size and form. The road would have likewise moved inland, always running between the foot of the dune and the head of the Pamet. Once paved, the road was fixed, but the dune was not and its encroachments upon the road were necessarily removed.
>
> Thus the sustenance, natural movement and protective qualities of this barrier dune were upset. As a esult, this important natural protection has deteriorated and washovers occur with greater frequency. (Giese and Giese, 1974)

Natural dune processes are upset by the pedestrian and by vehicular access at Ballston Beach. A boardwalk should be provided over the dune, grass should be planted and vehicle access should be prohibited. If the dune is to be allowed to retreat naturally, the section of road behind the dune should be removed and abandoned, and any structures on the dune should be moved.

This section of the Cape with its steep bluffs and limited beach access is very susceptible to vehicular and pedestrian abuse by their disregard for plant life and dune stability in their quest to reach the beach. Uncontrolled walking or driving on dunes or beach grass should be minimized. Vegetative growth, as suggested in Volume II Appendix 4 of this report, should be part of a regular program on the steep slopes and along the dune crest. If necessary, artificial nourishment or dune building with grass planting and fertilization should be implemented. Strict enforcement of the regulations is necessary to emphasize to the violators the importance of dune stabilization. Mandatory fines and classroom attendance could be used as a tool to educate the populace in this very important matter.



TOWN LOCATION MAP

TRURO

BEACH EROSION CONTROL STUDY

CAPE COD EASTERLY SHORES

CORPS OF ENGINEERS

A B C D E F G H

U. S ARMY

1 2 3 4 5 6 7 8

TRURO

BEACH EROSION CONTROL STUDY

CAPE COD EASTERLY SHORES

PLATE B-2

SECTION C

WELLFLEET

Photo 1. August 1977. A panoramic look to the south at Newcomb Hollow Beach, Wellfleet.

Photo 2. August 1977. Newcomb Hollow Beach, Wellfleet.

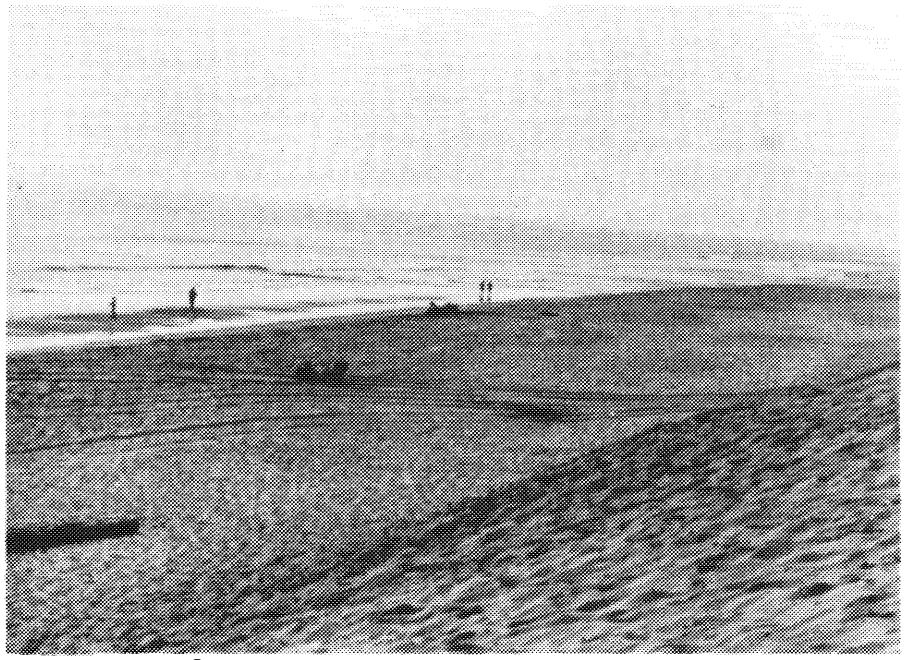


Photo 3. August 1977. A view to the south on Cahoon Hollow Beach, Wellfleet from the base of the scarp.

Photo 4. November 1977. A view to the south through the dunes on LeCount Hollow Beach, Wellfleet. Merriam grass in picture is a key dune builder in beach processes.

Photo 5. November 1977. A view to the north from the Marconi Site, Wellfleet.

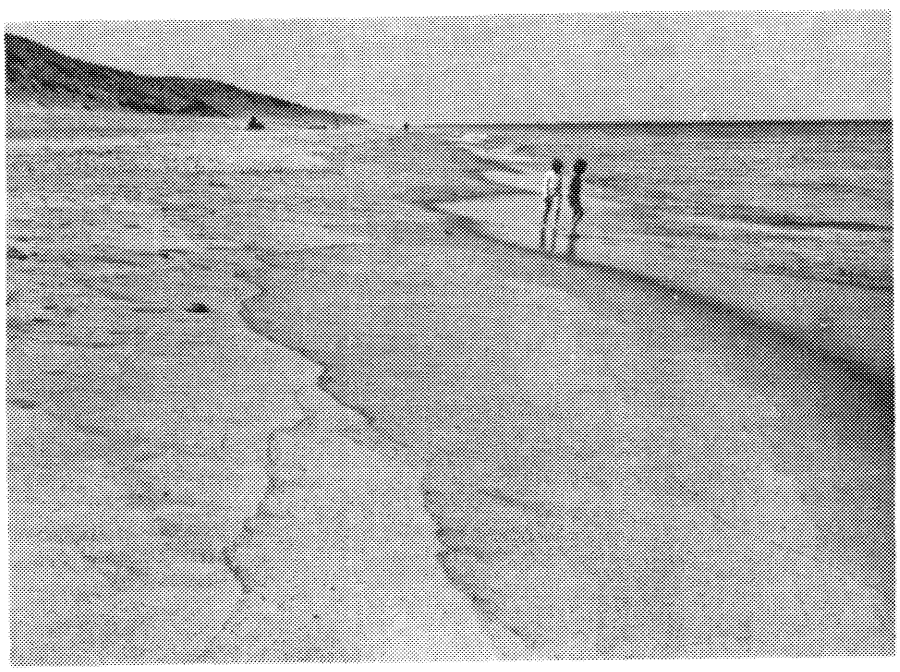


Photo 6 . April 1977. A moment of serenity on Marconi Beach.

WELLFLEET

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WELLFLEET

GENERAL

The complete length of Wellfleet's outer beaches (Figure 17) is backed by a high scarp ranging in height from more than 100 feet in the north to approximately 50 feet in the south. The high scarp is marked by depressions or pamets formed by the intersection of previous glacial streams. These pamets or hollows provide access routes to Wellfleet's beaches.

In general, there are few structures near the edge of the scarp, but Wellfleet by the Sea and LeCount Hollow contain over 100 houses and cottages. Some have been seriously threatened by the continued erosion of the scarp, and a few have been moved after the storms of 1978.

LOCATION AND DESCRIPTION OF BEACHES

Newcomb Hollow Beach and Cahoon Hollow Beach

Location - Between the Truro-Wellfleet town line and the parking area north of Wellfleet by the Sea (Figure 18).

Shore Length - 2.4 miles.

Ownership - Town of Wellfleet.

Beach Use - Swimming, fishing, surfing (White Crest Beach).

Public Facilities - Parking area for approximately 280 cars at Newcomb Hollow Beach and parking for approximately 80 cars in parking area north of Wellfleet by the Sea.

Beach Width - 70 to 170 feet to face of scarp backed by 80- to 110-foot high scarp.

Composition of Shore - Fine-grained sand in north and coarse-grained sand in south.

Protective Structures - None.

Shore Structures - Approximately 30 seasonal cottages are located 300 to 800 feet from the edge of the scarp.

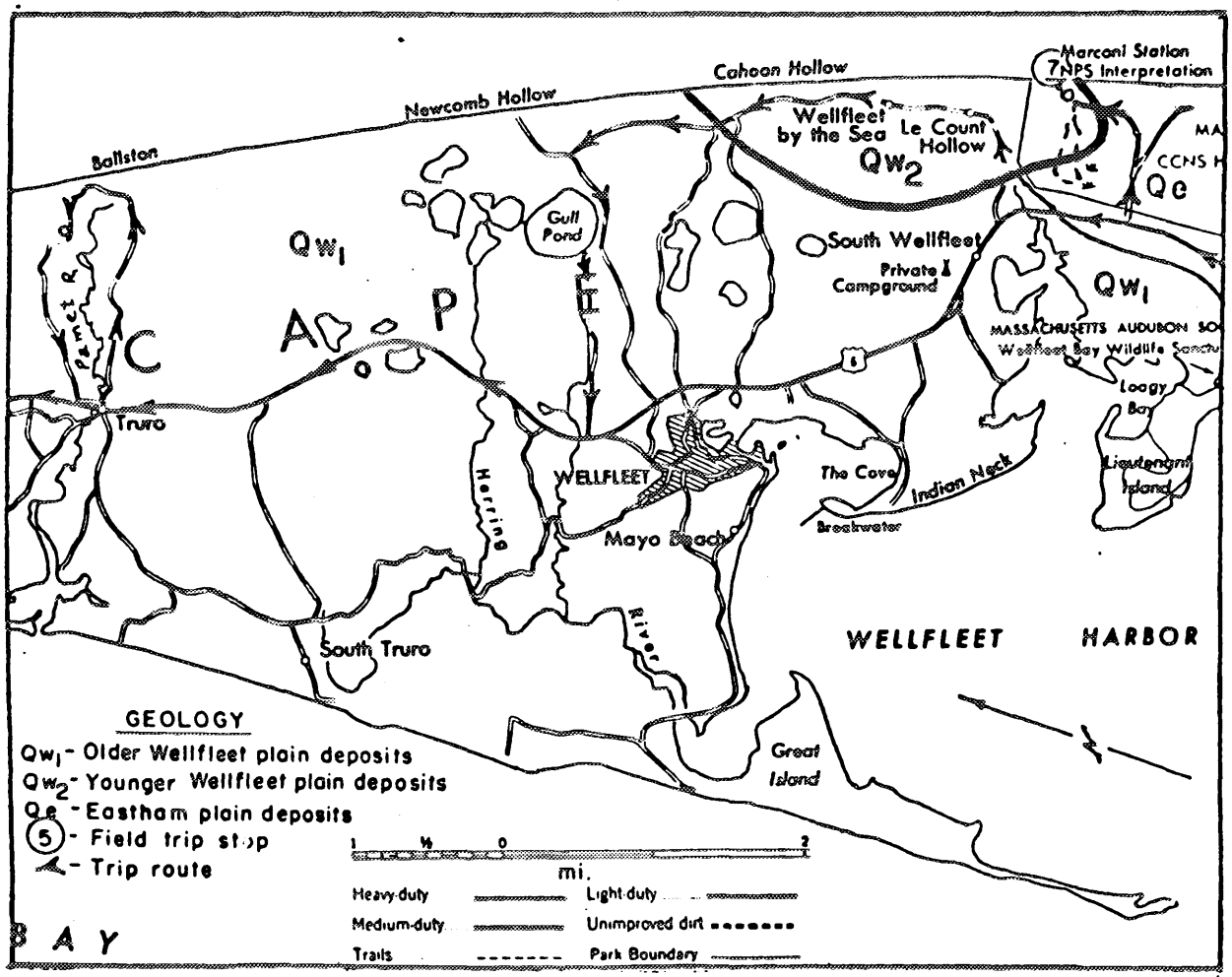


Figure 17. Wellfleet, Massachusetts (after Fisher, 1972)

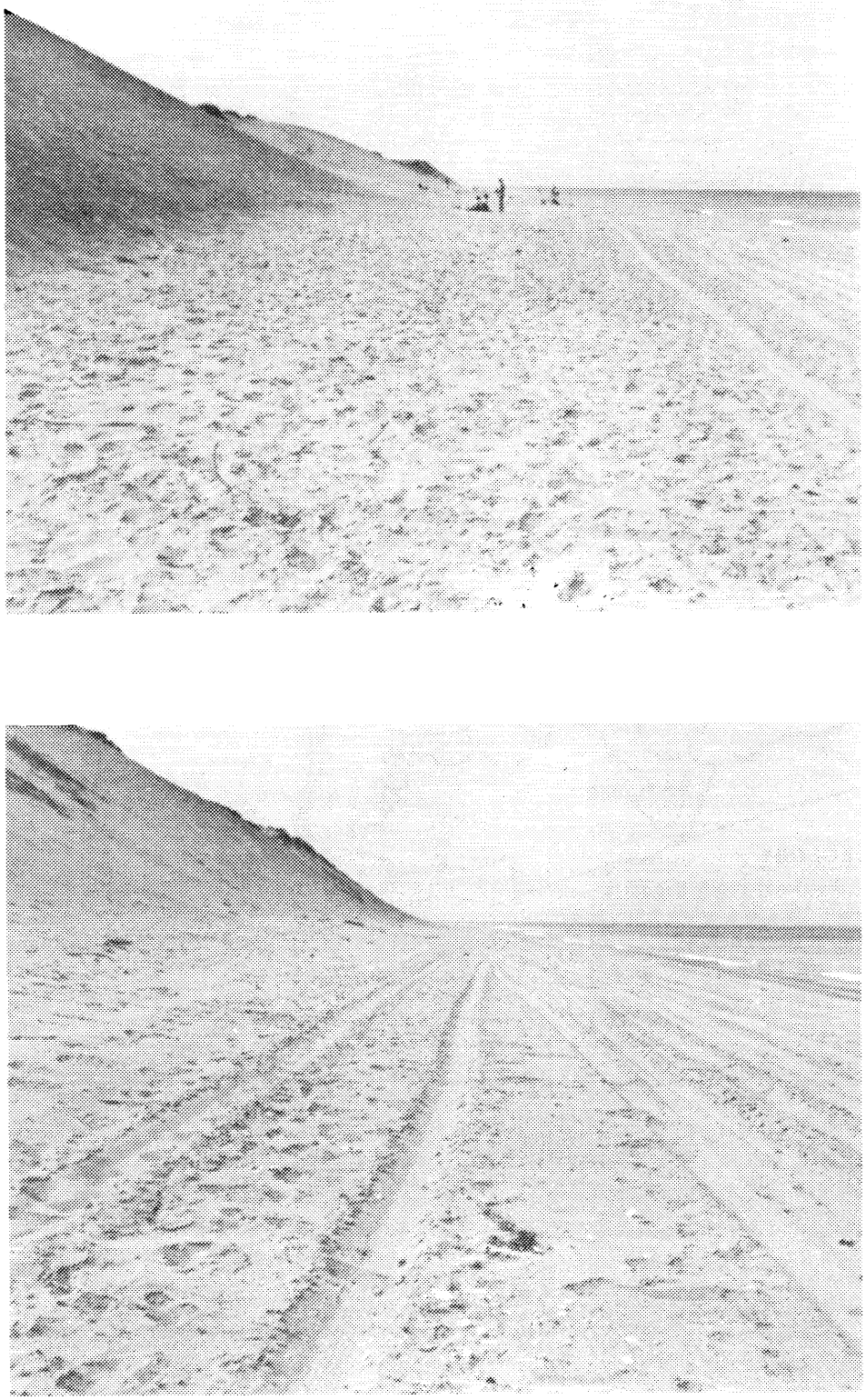


Figure 18. Newcomb Hollow Beach (top) and Cahoon Hollow Beach (bottom), Wellfleet, Massachusetts, April 1977

Character of Development - The beach itself is not developed, but there are nearly 50 houses west of Newcomb Hollow Beach and around Gull Pond. Ocean View Drive more or less parallels the shoreline, being closest to the shoreline at the parking area at the south end of Cahoon Hollow Beach.

LeCount HollowBeach

Location - Between the parking area north of Wellfleet by the Sea and the Marconi Station site (Figure 19).

Shore Length - 1.4 miles.

Ownership - Town of Wellfleet.

Beach Use - Swimming.

Public Facilities - Parking area for approximately 100 cars along the north side and at the end of LeCount Hollow Road.

Beach Width - 55 to 70 feet to base of scarp backed by 80-foot high scarp.

Composition of Shore - Fine-grained beach sand with gravel at washline. Beach is backed by an 80- to 100-foot high, grass-covered, sandy scarp broached by a pamet sag, LeCount Hollow.

Protective Structures - None.

Shore Structures - There are numerous cottages and houses within 1000 feet of the shoreline.

Character of Development - Wellfleet by the Sea and LeCount Hollow are substantial settlements including approximately 150 buildings, most of which are more than 100 feet from the edge of the dune.

Marconi Beach

Location - Between the Marconi Station site and the Wellfleet-Eastham town line (Figure 20).

Shore Length - 2.4 miles.

Ownership - National Park Service.

Figure 19. LeCount Hollow Beach, Wellfleet, Massachusetts, April 1977

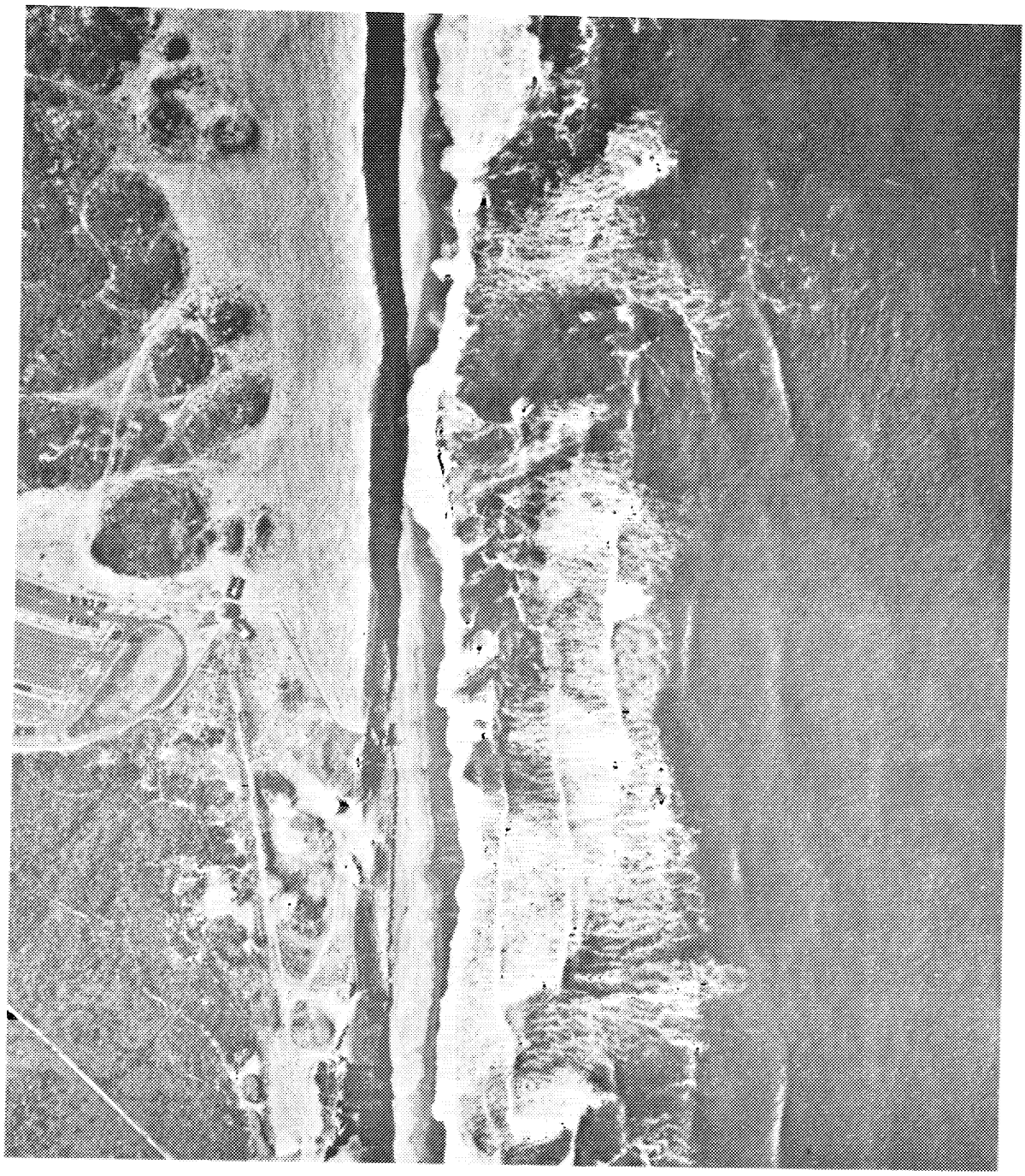


Figure 20. Aerial photograph of Marconi Beach, Wellfleet, Massachusetts, April 1978

Beach Use - Swimming.

Public Facilities - Bathhouse, parking for 528 cars, and boardwalks with stairs leading down the scarp to the beach.

Beach Width - 100 to 150 feet in summer; may be 20 feet or less during winter months.

Composition of Shore - Fine-grained beach sand with gravel at washline. The beach is backed by a 40- to 50-foot high, grass-covered scarp which is readily eroded by wave action. One-third of the way down the cliff face is the contact between the younger and older Wellfleet outwash plain glacial deposits. The older (lower) unit is composed of fine to very coarse gravelly sand. However, within this unit are beds and lenses of pebble and cobble gravel, fine to very fine sand and clayey silt. Boulders, tens of feet in diameter, are common and some pebbles in the deposit are wind-polished. (The boulder-bearing formations have not been exposed on the beach scarp yet.) Planar bedding, crossbedding and current ripples are evident. Reworked fossil material includes carbonized wood and shells of Pleistocene age, fossiliferous sandstone cobbles, silicified wood, and fish teeth (Fisher, 1972; Oldale, 1968). There is a dominance of quartzite stones.

The second, younger unit of the Wellfleet deposit is similar to the older Wellfleet deposit except that the boulders and clayey silt beds are not present. Planar and tabular bedding and crossbedding are evident (Fisher, 1972; Oldale, 1968). The dominant lithologic material is granitic.

The material eroded from these deposits is transported south to Nauset Beach.

Protective Structures - None.

Shore Structures - Several buildings belonging to the National Park Service house the headquarters of the Cape Cod National Seashore. Roads and beach facilities, including boardwalks and stairs leading down the scarp to the beach, have also been built in the area.

The north end of Marconi Beach was the location of Guglielmo Marconi's permanent wireless radio station that established contact with Cornwall, England, in 1903. The station was dismantled in 1920 and subsequently the U.S. Army constructed Camp Wellfleet on the same site.

Character of Development - Since the placement of Marconi's four steel towers in 1902, the scarp has eroded 170 feet, an average rate of 2.4 feet per year. The two concrete bases have crumbled to the beach below and the foundation of the powerhouse on the edge of the bluff is being eroded (Fisher, 1972). The location of the original towers at the Marconi Station site is now over 50 feet into the sea.

STATEMENT OF THE PROBLEM

All of Wellfleet's eastern shore consists of a beach of varying width backed by a 50- to 120-foot high scarp. Winter storms, northeasters, rain and winds continue to erode the scarp causing it to retreat westward. The material eroded from the scarp is carried by littoral transport to nourish the beaches north and south of Wellfleet. The exact location where longshore transport changes direction is unknown, but wave refraction analysis places it near LeCount Hollow Beach (Cornillon et al, 1976).

Except for Wellfleet by the Sea and LeCount Hollow, there are few structures located close to the edge of the scarp; however, in Wellfleet by the Sea and LeCount Hollow, nearly 100 houses and cottages have been built within 1,000 feet of the edge. As a result of the storms of the winter of 1977-78 a few of these houses were so severely undermined that they had to be moved. Further erosion of the scarp will continue to undermine the foundations of these houses causing them to fall down the slope if they are not moved back from the edge. The owners are imminently threatened by the continued retreat of the shoreline.

At most beaches in Wellfleet, access to the beach is unlimited or uncontrolled. People living in houses at the top of the scarp and visitors parking in the parking lots approach the beach from any convenient location. Each step on the face of the scarp loosens the sand and moves it down the scarp. These processes make the scarp face more vulnerable to wind, rain and wave erosion, and thus hasten the retreat of the scarp. If this retreat cannot be controlled from the ocean side, at least the steep slope of the scarp could be protected by the provision of stairways at designated locations. One of the few sets of wooden stairs to the beach is found at Marconi Beach, managed by the National Park Service.

Beach buggies are allowed nearly free access to the beach at LeCount Hollow Beach. This traffic disturbs the scarp surface, further contributing to its erosion and retreat. LeCount Hollow Beach appears to be the only access route from the top of the scarp in Wellfleet. Protection from vehicular as well as pedestrian traffic is needed.

Marconi Beach does not appear to have any specific problems other than the one felt the length of the outer Cape. The scarp is being eroded by the elements and, in time, roads and structures will be threatened. North of Marconi Beach there is beach grass on the top of the scarp but little vegetation on the slope. Approximately 0.6 miles north of the Marconi Beach parking area the beach is so narrow that the waves are breaking against the bottom of the scarp. The scarp can be expected to slump and retreat in that area.

Any solution that would halt the retreat of Cape Cod's outer shore would also help Marconi Beach but no specific measures seem to be warranted at this time.

SHORE PROCESSES

Waves approaching Wellfleet (Figure 21) from the east and southeast can produce northerly longshore currents. Waves from the south and south-southeast that might also produce northerly currents are omitted from the wave refraction analysis and their contribution to longshore transport is assumed to be small (Cornillon et al, 1976).

The exact location where net longshore transport changes direction from north to south is unknown. Several researchers have suggested Wellfleet as the probable location (Hartshorn et al, 1967; Fisher, 1972; Cornillon et al, 1976). The wave refraction analysis places the location at the 20-mile mark near LeCount Hollow Beach (Cornillon et al, 1976). Therefore, the 20-mile mark is predicted to be a nodal point (location at which the longshore transport changes direction). Material is transported south below this location and north above it. No fulcrum points (locations at which the longshore transport attains a maximum or minimum and no net erosion or accretion occurs) were identified along the Wellfleet coast by the wave refraction analysis.

The erosion rate predicted by the wave refraction analysis and the resultant amount of shoreline retreat are shown in Figure 22. Erosion rates of 2 to 4 feet per year with the maximum erosion occurring at the 20-mile mark are predicted for this section of coast. These rates agree with the rates determined by Zeigler and his associates (1964a).

METHODS OF CORRECTING THE PROBLEM

The problem of pedestrian and vehicular access is not unique to the Wellfleet beaches. Newcomb Hollow and Cahoon Hollow beaches front fairly high bluffs or backshore dunes making easy access to the shore difficult. Every effort should be made to prevent visitors from walking, sitting or driving either on or behind the bluffs or dunes unless it has been designated as a recreational use area and is controlled.

LeCount Hollow Beach has a similar problem. Because the backshore bluff has a relatively flat scarp, it is tempting to slide down or to walk on the scarp, resulting in deterioration of the bluff or backshore dune.

Every effort should be made to control and minimize the use of the dune or bluff for private individual pleasures. Planting and fertilization to promote healthy growth along backshore areas should be encouraged and heavy fines and strict enforcement of the regulations should be implemented to insure protection of this natural protective barrier. Controlled access to the beaches from parking lots and vantage points along roads will minimize the abuse now being experienced and encourage healthful recreational use of the areas. Drainage of backshore parking areas should be directed away from the beach rather than toward the beach. Collecting ponds or areas should be designed for this purpose.

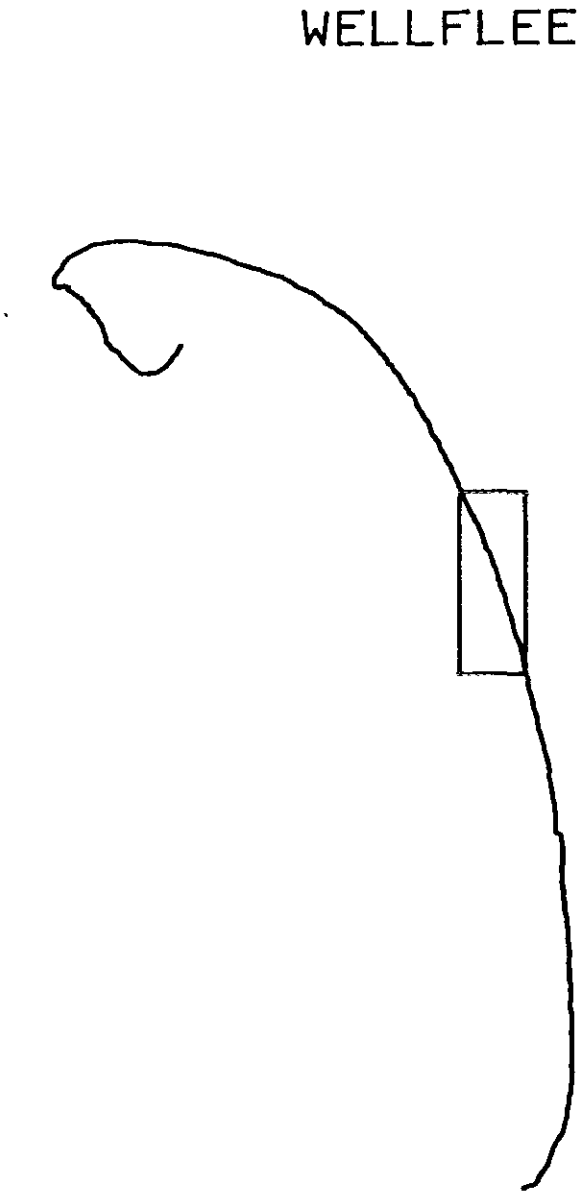


Figure 21. Atlantic coast of Wellfleet, Massachusetts - location of area shown in Figure 22

WELLFLEET

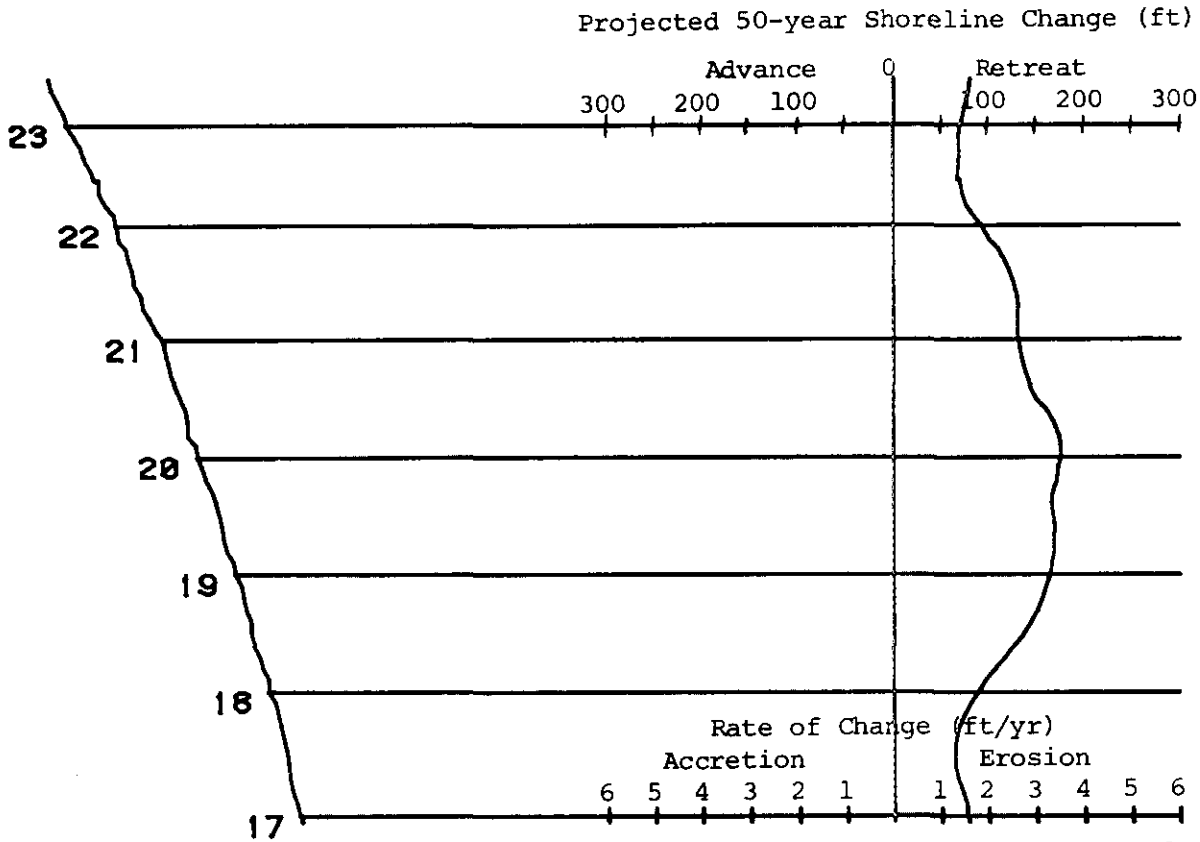
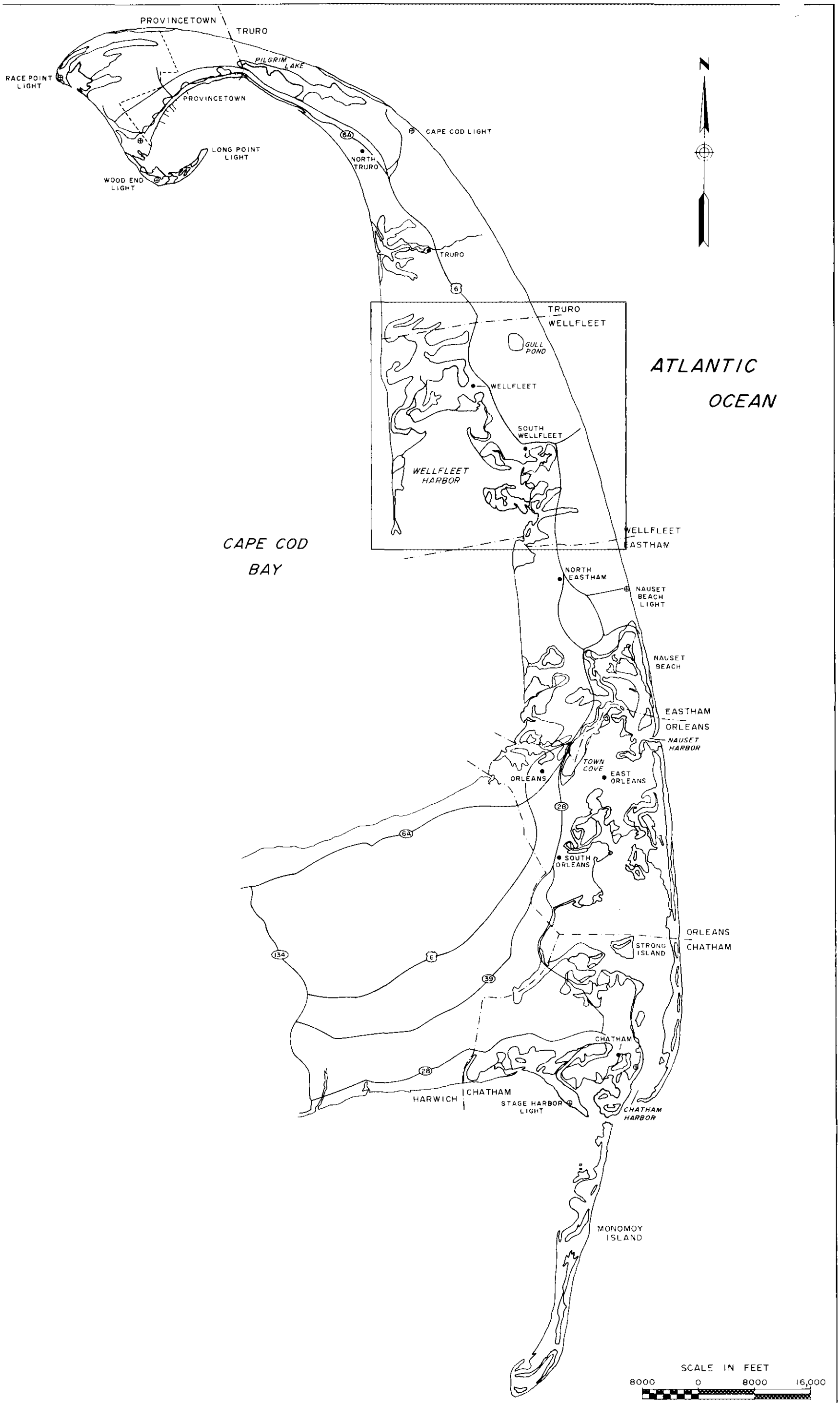


Figure 22. Projected erosion/accretion rates and shoreline changes for the Atlantic coast of Wellfleet, Massachusetts

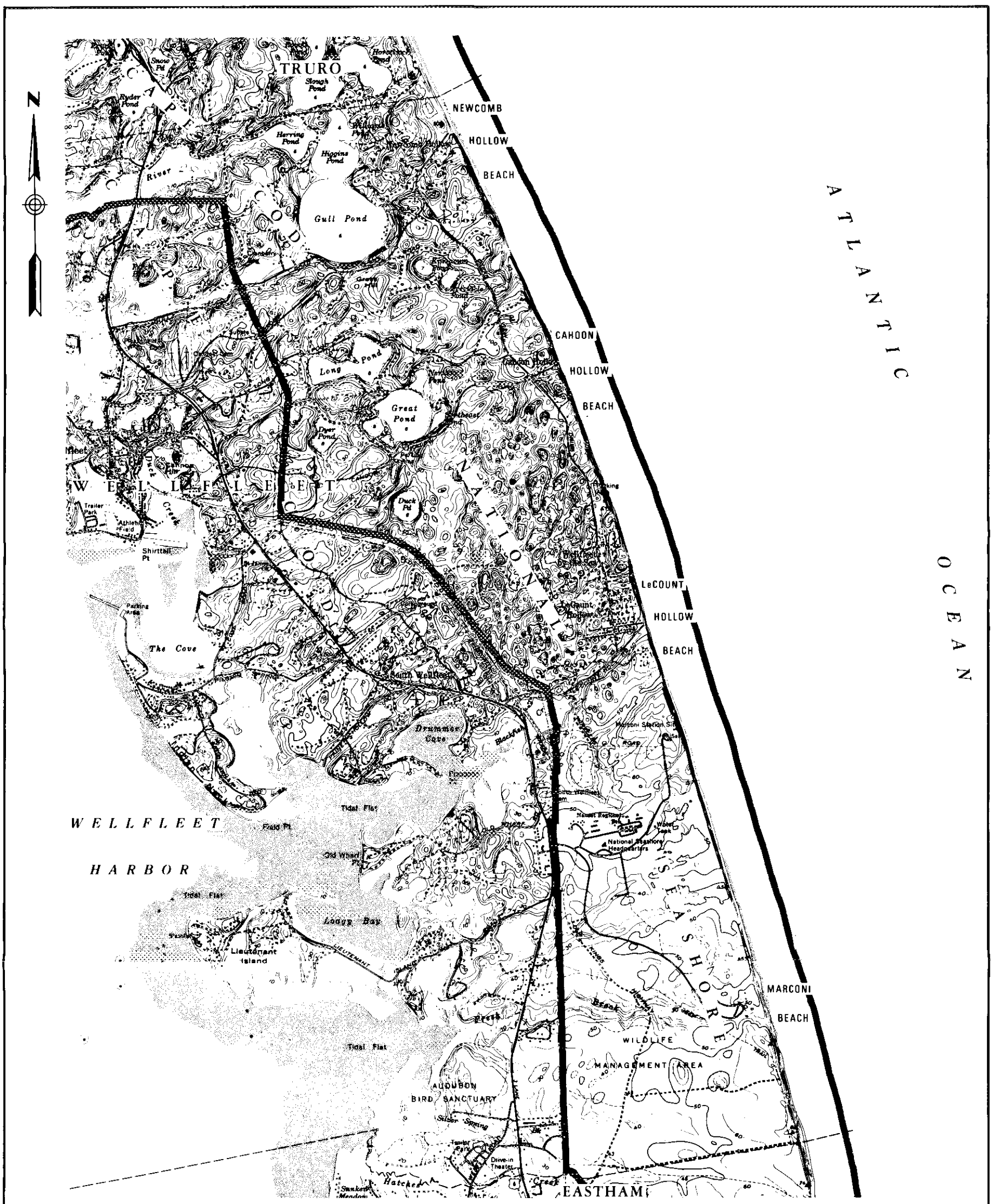


TOWN LOCATION MAP

WELLFLEET

BEACH EROSION CONTROL STUDY

CAPE COD EASTERLY SHORES



WELLFLEET

BEACH EROSION CONTROL STUDY

CAPE COD EASTERLY SHORES

PLATE C-2

SECTION D

EASTHAM

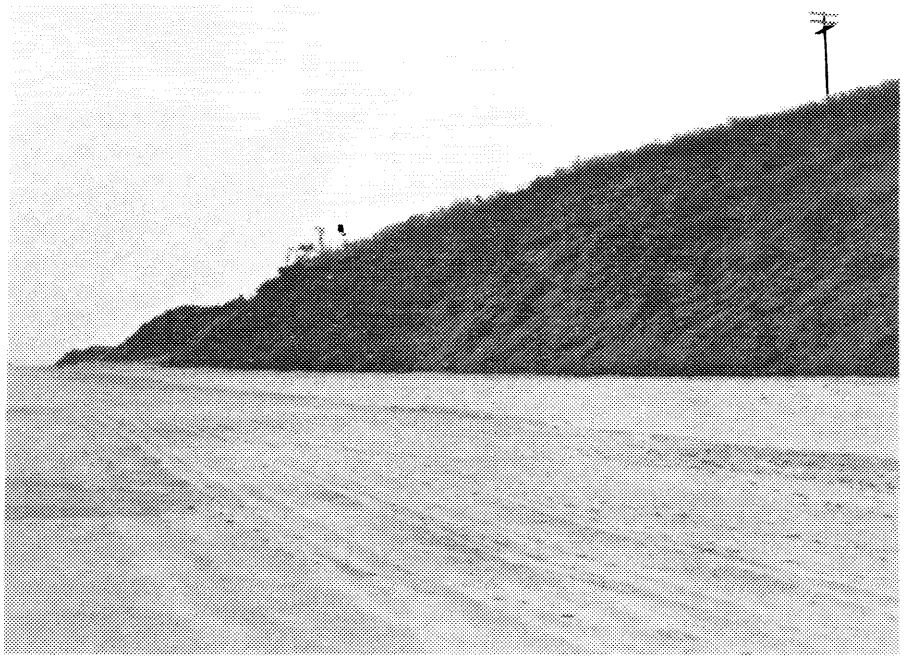


Photo 1. April 1977. Eastham town line looking south towards Nauset Light Beach.

Photo 2. February 1971. Looking north from Nauset Light parking area across eroded pavement onto the beach.

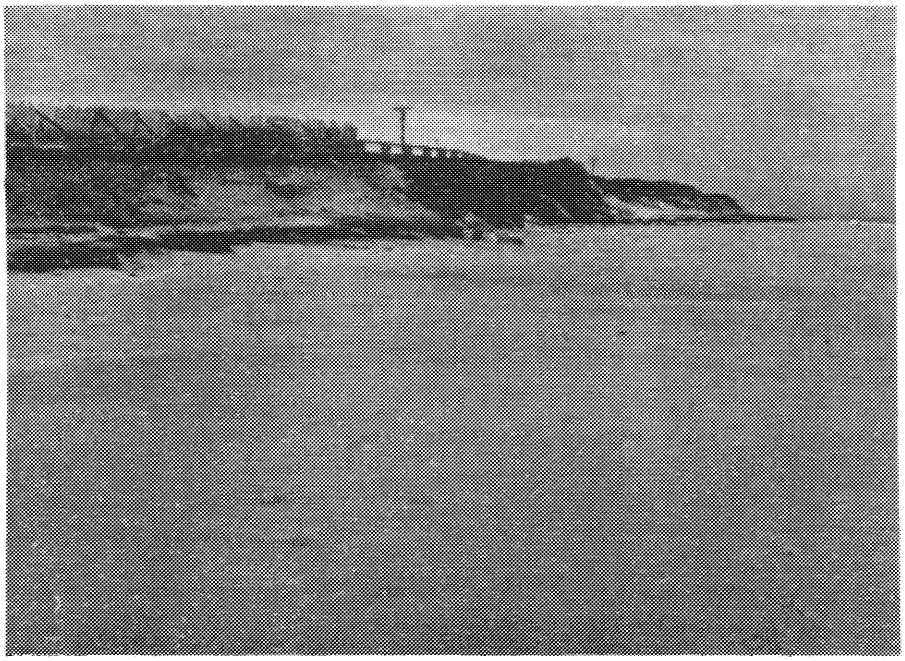


Photo 3 . November 1977. A view of the eroded parking area at Nauset Light taken from the beach.

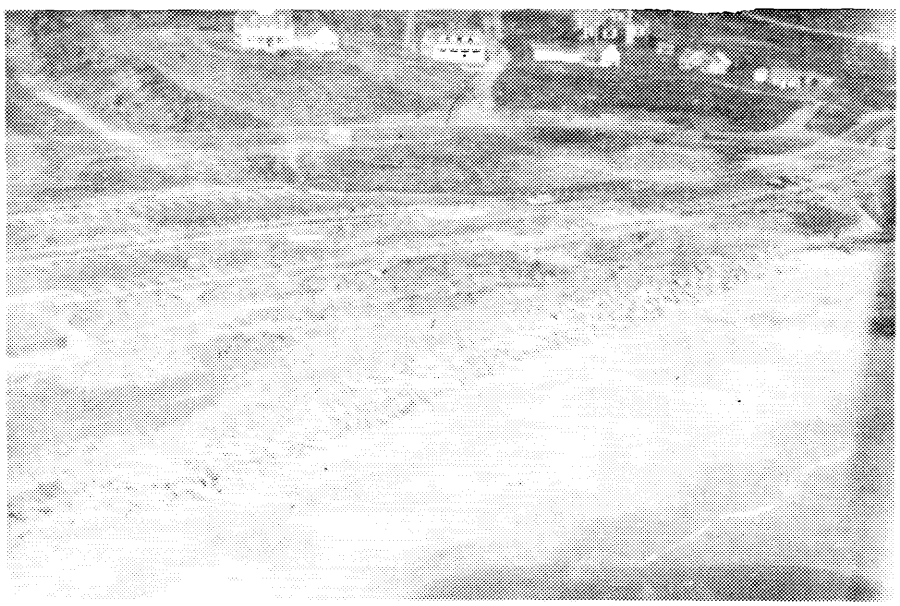


Photo 4 . June 1967. An aerial view of Coast Guard Beach, Eastham and parking area. Note distance between beach and parking area.

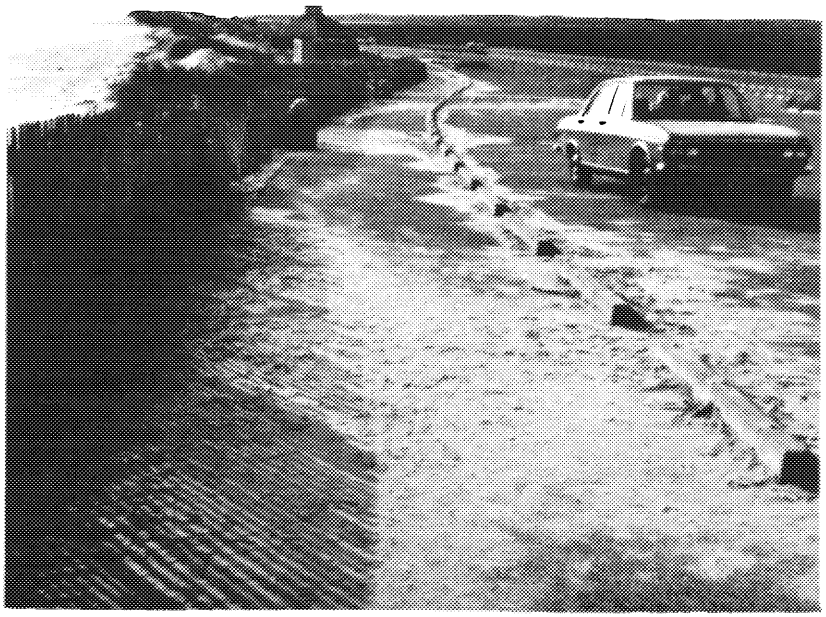


Photo 5. November 1977. A recent photo of bathhouse at Coast Guard Beach. Compare bathhouse's distance from the beach with the 1967 aerial in Photo 4.

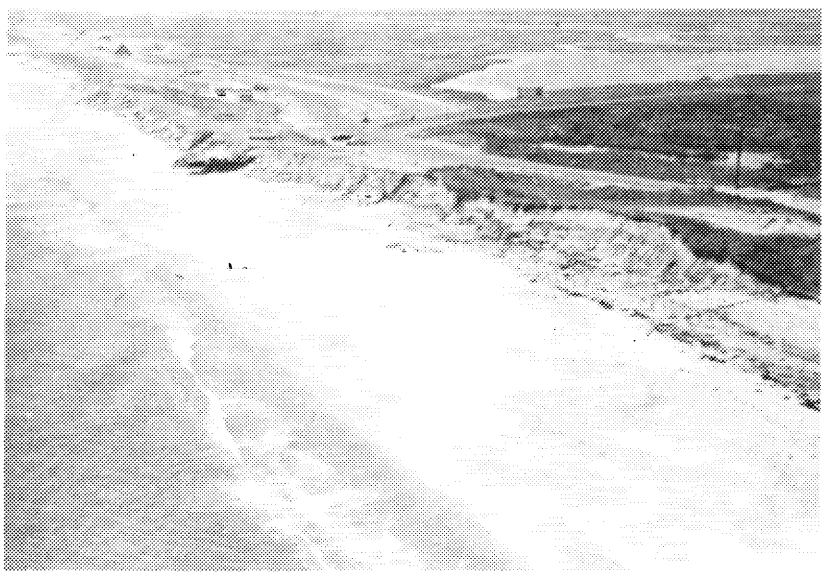


Photo 6. June 1967. A twelve year old aerial panoramic view of Coast Guard Beach and parking area.

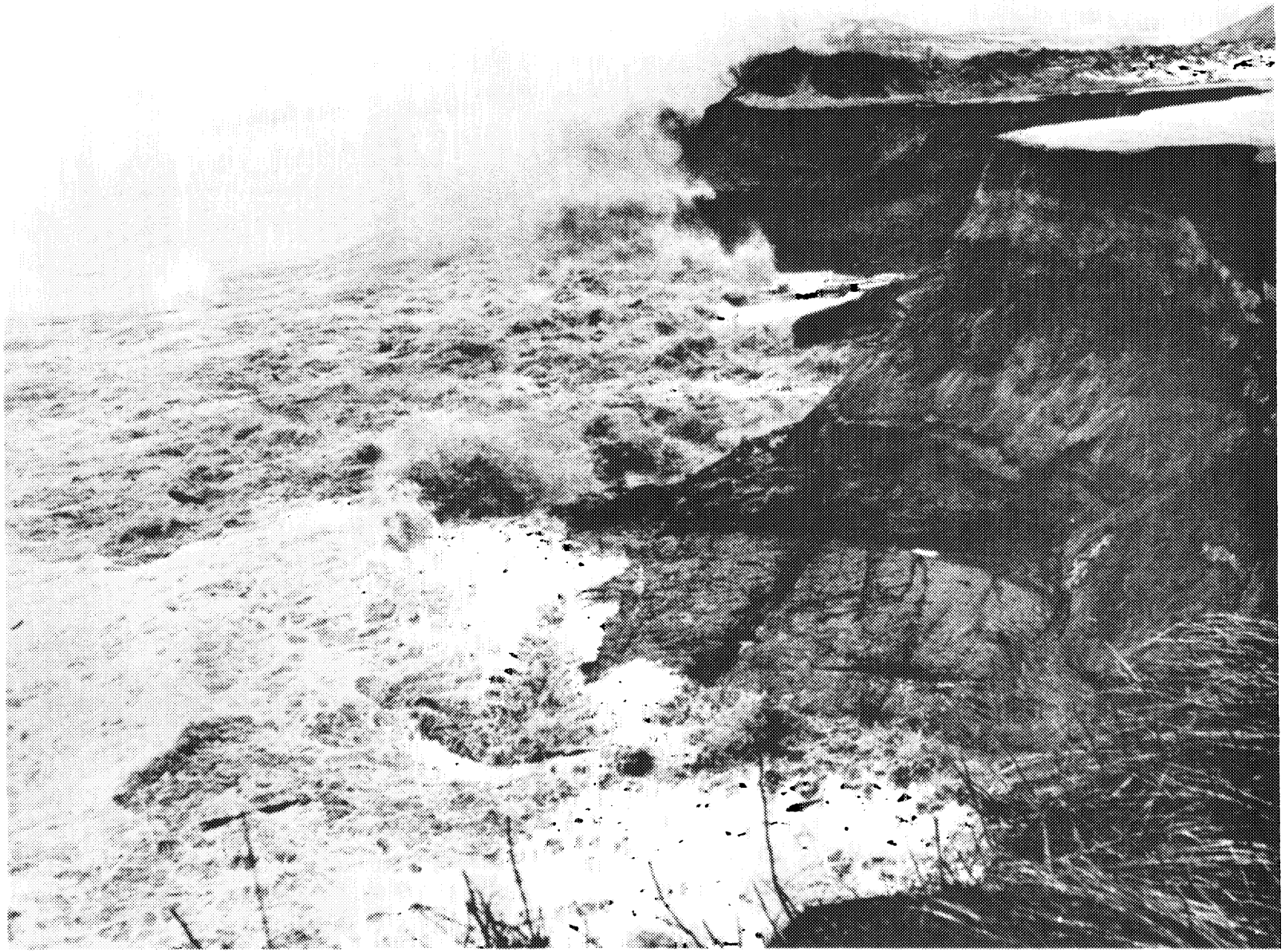


Photo 7. Coast Guard Beach during a storm. Note extent of wave runup.

Photo 8 . Coast Guard Beach after storm looking south showing extent of erosion.

EASTHAM

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EASTHAM

GENERAL

Most of Eastham's eastern shoreline (Figure 23) is known as Nauset Beach and consists of two types of beaches with the dividing line occurring at Coast Guard Beach. North of Coast Guard Beach, Nauset Beach is approximately 200 feet wide and is backed by a 50-foot scarp carved from the glacial deposits forming the mainland of the Cape. South of Coast Guard Beach, Nauset Beach is the eastern side of a long, sandy spit that formed during the past 1,000 years from the sands that were eroded from the glacial deposits to the north and carried south by longshore currents. This long spit has been subject to washovers, and the inlet to Nauset Harbor has been located in various places along it, both north and south of the Eastham-Orleans town line.

LOCATION AND DESCRIPTION OF BEACHES

Nauset Beach 1

Location - Between the Wellfleet-Eastham town line and a point 2000 feet north of Nauset Beach Lighthouse.

Shore Length - 1.1 miles.

Ownership - National Park Service.

Beach Use - Mostly swimming.

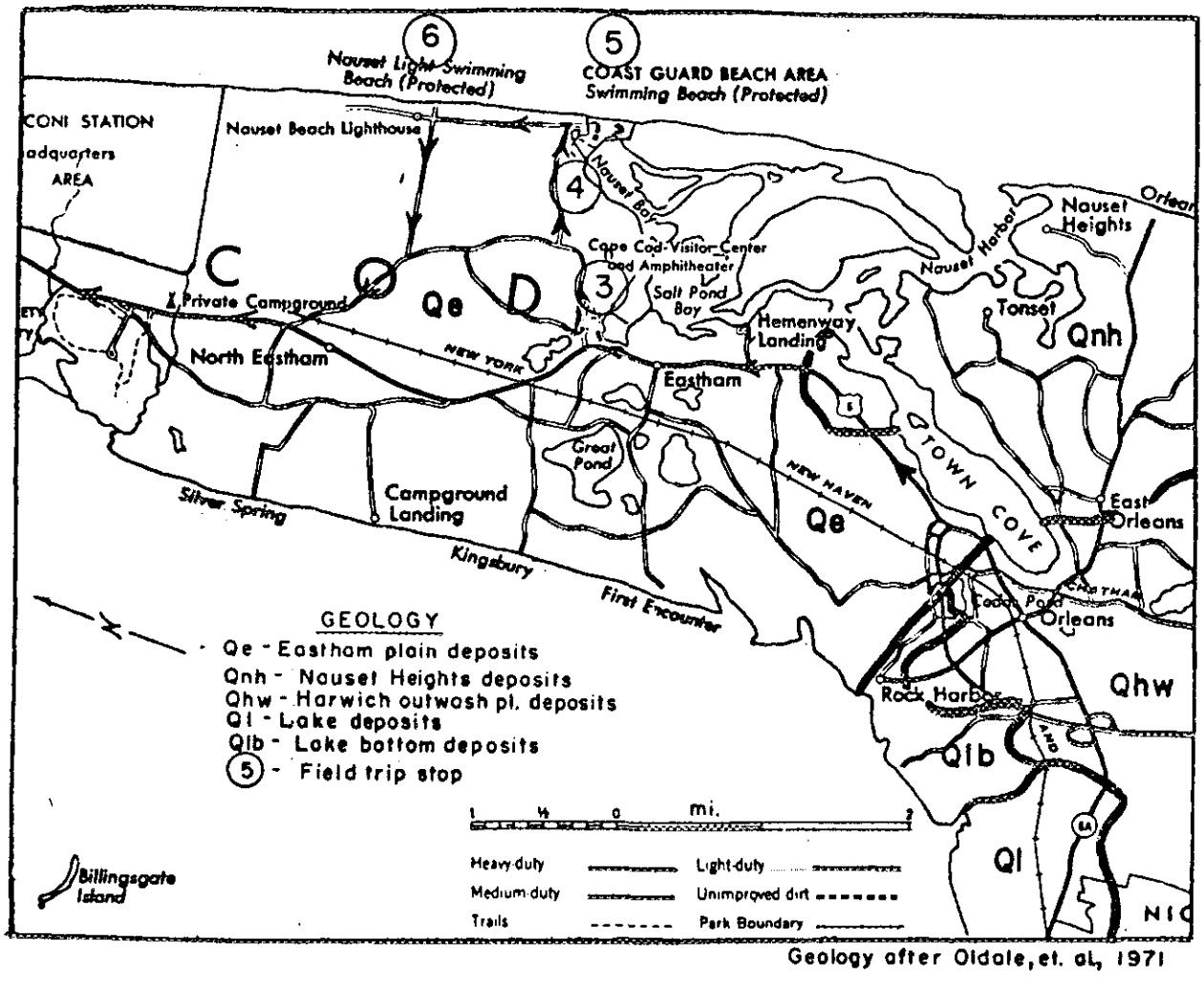
Public Facilities - None.

Beach Width - 100 to 200 feet.

Composition of Shore - Fine-grained beach sand above and below high water backed by a 50-foot high, near-vertical scarp. The top of the scarp is covered by small oak and pine trees.

Protective Structures - None.

Shore Structures - A paved road approximately 200 feet west of the edge of the scarp extends 0.9 miles north from Nauset Beach Lighthouse. The road continues north as a dirt road and jeep trail much closer to the edge of the dune, running down to the beach in places.



Geology after Oldale, et. al, 1971

Figure 23. Eastham, Massachusetts (after Fisher, 1972)

Character of Development - A few houses are located west of the road at the southern end of this portion of Nauset Beach.

Nauset Light Beach

Location - Between a point 2000 feet north of Nauset Beach Lighthouse to a point 200 feet south of the lighthouse. (Figure 24).

Shore Length - About 0.4 miles.

Ownership - National Park Service.

Beach Use - Mostly swimming.

Public Facilities - Parking area on bluff 50 feet above beach; several wooden stairways provide access to beach; lifeguard protection provided for approximately 600 feet of beach during the summer.

Beach Width - 200 to 250 feet.

Composition of Shore - Fine-grained beach sand backed by 50-foot high bluff.

Protective Structures - None.

Shore Structures - Nauset Lighthouse, the only visual navigation aid between Chatham and Highland Light in Truro, was originally built as three fixed light towers in 1837. It was later replaced by a single revolving light. All the towers were destroyed as the eroding bank moved inland and Nauset Beach Lighthouse was moved 200 feet westward to its present location in 1923.

The parking lot is located only 5 to 12 feet from the edge of the dune and is in danger of being undermined as erosion continues.

Character of Development - Several houses have been built along the top of the dune north of the lighthouse.

Nauset Beach 2

Location - Between a point 200 feet south of Nauset Beach Lighthouse and Coast Guard Beach.

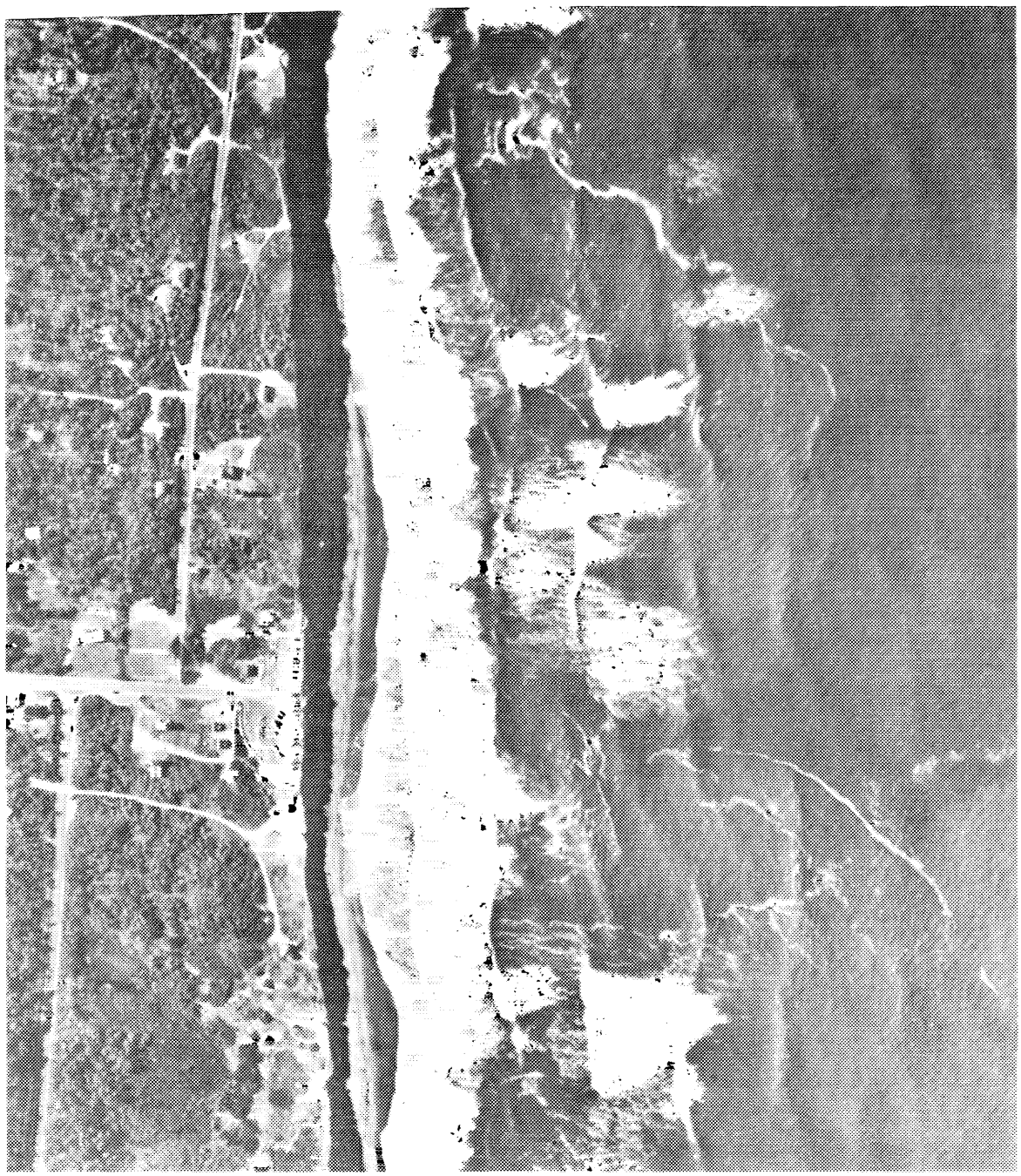


Figure 24. Aerial photograph of Nauset Light Beach, Eastham, Massachusetts, April 1978

Shore Length - Approximately 1 mile.

Ownership - National Park Service.

Beach Use - Mostly swimming.

Public Facilities - Large parking area and bathhouse existed at Coast Guard Beach prior to the storm of February 1978.

Beach Width - 200 to 225 feet.

Composition of Shore - Fine beach sand. The northern half of the beach is backed by a steep 50-foot high scarp. In 1965 an exposure in the lower part of the scarp showed 10 feet of till underlain by 2 feet of sand and gravel underlain by a minimum of 3 feet of laminated silt (Fisher, 1972). The southern half of this portion of Nauset Beach is backed by low (10- to 20-foot high), narrow dunes that separate the ocean from a marsh leading to Nauset Bay.

Protective Structures - None.

Shore Structures - None.

Character of Development - A few houses are located 200 to 1000 feet from the edge of the dune.

Coast Guard Beach

Location - At the northern extremity of North Spit, the long spit that extends southward from the glacial mass of Cape Cod north of Nauset Bay.

Shore Length - 0.6 miles.

Ownership - National Park Service.

Beach Use - Swimming.

Public Facilities - Large parking area and bathhouse at Coast Guard Beach until February 1978; lifeguard protection provided for approximately 1000 feet of beach during the summer.

Beach Width - 100 feet in summer, 50 to 75 feet in winter.

Composition of Shore - Fine beach sand above and below high water backed by 10- to 20-foot high dunes the length of the beach. These dunes are all that separate the ocean from Nauset Bay and the marshes that drain into the bay.

Exposure of peat deposits 1 to 5 feet thick under the seaward side of the dunes on the spit is indicative of westward movement of the spit as a whole (Zeigler, 1956).

Protective Structures - None; dune grass plantings at Coast Guard Beach to control wind erosion.

Shore Structures - A few seasonal cottages are located on the dunes; a jeep trail runs along the base of the west side of the dunes.

A bathhouse and large parking lot were located close to the edge of the dune until the northeaster of February 1978 damaged them both. Figure 25 shows Coast Guard Beach as it was in April 1978, two months after the storm.

Character of Development - Federally and town-owned land is open to the public for bathing and fishing. Private land has several seasonal homes. The beach is used extensively during the summer by fishermen with beach buggies.

Nauset Beach 3

Location - Between the southern end of Coast Guard Beach east of Nauset Bay and the Eastham-Orleans town line. At various times, as at present, this area has included the inlet to Nauset Harbor. From 1887 to 1952 the inlet was located in Orleans.

Shore Length - 1.8 miles.

Ownership - National Park Service and private.

Beach Use - Prior to February 1978 the beach was open to vehicular traffic allowing use by campers and fishermen with beach buggies. After the storm of February 1978, beaches in this area were closed to all vehicular traffic.

Public Facilities - None.

Beach Width - 50 to 100 feet for northern 1.3 miles, southern 0.5 miles is spit, ranging in width from 500 to 1000 feet.

Composition of Shore - Fine beach sand above and below high-water line. Northern 1.3 miles are backed by 10- to 20-foot high dunes; the southern half-mile of the spit, south of the inlet, was less than 10 feet above high water in September 1978 and is frequently overwashed.

Protective Structures - None.

Shore Structures - A few seasonal cottages are located behind the dunes.

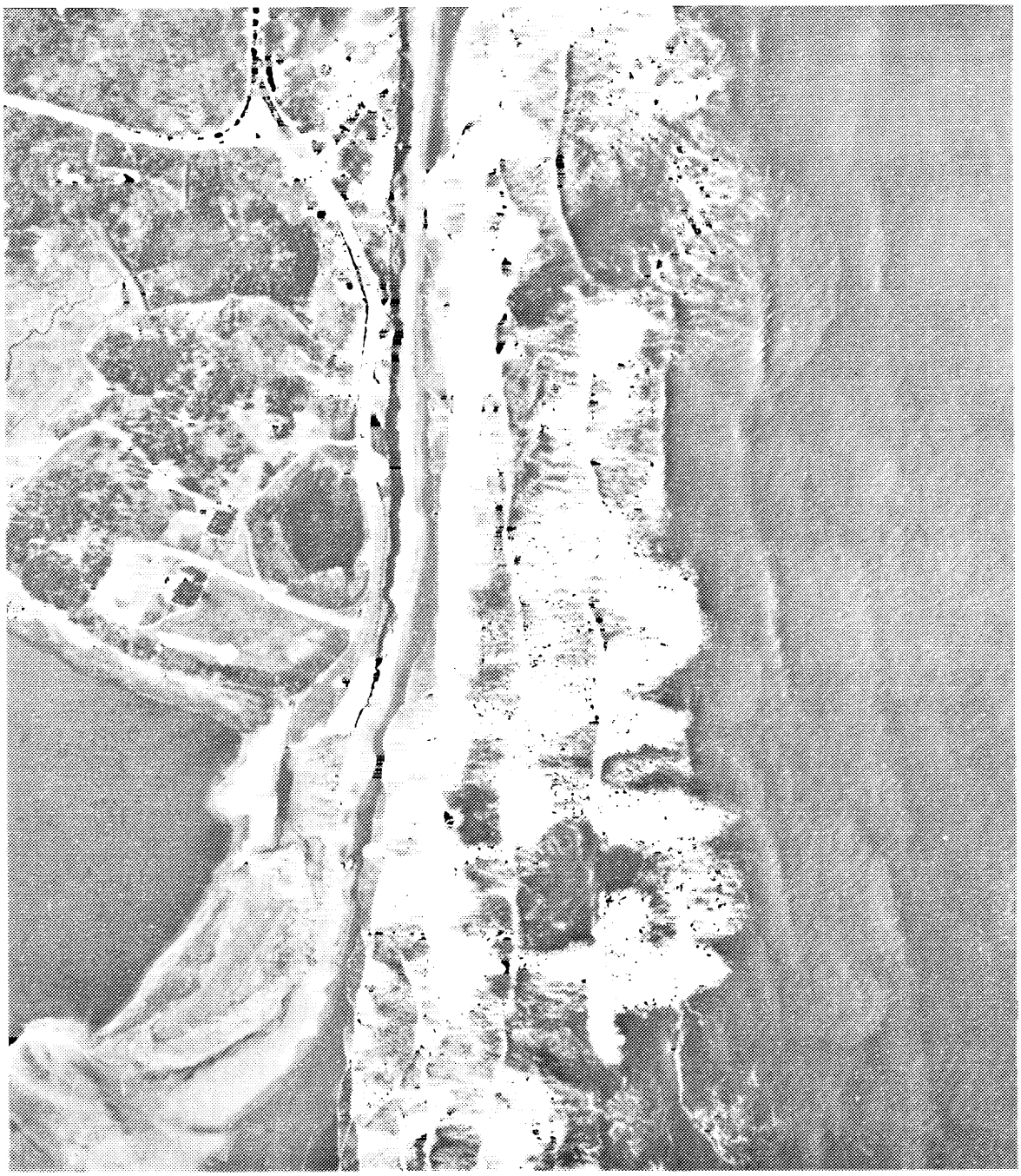


Figure 25. Aerial photograph of Coast Guard Beach, Eastham, Massachusetts, April 1978

Character of Development - Vehicular access to this beach has been limited since the severe storm of February 1978.

STATEMENT OF THE PROBLEM

Eastham encounters several types of problems on its eastern shore. North of Coast Guard Beach, storms and wave action continue to erode the scarp causing retreat of the shoreline. Much of this portion of Eastham's shore is free of structures, but nearly 20 houses have been built within 1,000 feet of the edge of the scarp north of Nauset Light. These homes and the road along the top of the scarp will be threatened as the shoreline moves westward.

Erosion of the scarp is the major problem encountered at Nauset Light Beach. The parking area is on the very edge of the scarp. It has not yet been undermined but may be within a few years. Although the lighthouse is approximately 125 feet from the edge of the scarp, it could be threatened as erosion continues. Several other buildings associated with the beach area and the lighthouse would also be in jeopardy.

Two areas where pedestrian traffic to the beach has caused localized erosion of the scarp edge occur 650 and 1,000 feet north of Nauset Light. The northernmost area appears to provide access to the beach for the residents of the houses immediately to the west.

As with the rest of the scarp section of the outer Cape, some measure of erosion control is needed. Any protection provided for Nauset Light Beach would be part of an areawide plan. The provision of boardwalks and stairways at the other two access areas could lessen the erosion there.

The major problem at Coast Guard Beach is its survival. At present it is not clear whether the dune west of Coast Guard Beach can or will be reestablished as a barrier between the Atlantic Ocean and Nauset Bay or whether the breach and washover in the dune will widen and deepen causing North Spit to become an island. Either process could be temporary depending upon the effects of future storms.

Some controversy exists over the future course of action to be taken. The National Park Service prefers to leave the area of the major washover undisturbed, to observe and monitor the natural processes occurring there. Other individuals feel that all reasonable efforts at dune restoration and maintenance should be employed, including the use of sand fences and beach grass plantings. Previous experience on South Spit (the spit south of the inlet to Nauset Harbor) has indicated that dune restoration may not be a permanent solution but that it does minimize future damage to the dune, it is inexpensive, and it takes advantage of natural methods of sand transport by onshore winds and longshore currents (Knutson, 1977). If an inlet to Nauset Bay should develop at Coast Guard Beach, the resulting influx of colder, more saline water and transport of sand into Nauset Bay could significantly alter the environment in Nauset Bay, Salt Pond Bay and Nauset Harbor. If a break

occurs, it could have a disastrous influence on the commercial shellfish activities in the Bay (see Volume II Appendix 4 "pertinent correspondence" for letters on this matter). This alteration may ultimately occur in spite of man's efforts, but perhaps it could be forestalled.

The area from Coast Guard Beach south to the end of the grass-covered dunes is subject to numerous washovers that carry sand back to the edge of the salt marsh behind the dunes. If a washover area does not recover and fill with sand, it can become the site of future washovers and, eventually, lead to a breach in the dune.

SHORE PROCESSES

Waves approaching Eastham (Figure 26) from the north, northeast and northwest are principally responsible for southerly longshore currents on Eastham's coast, but northerly flow can occur when waves approach from the east and southeast. Waves from the south-southeast and south, which were omitted from the wave refraction analysis, might also produce longshore currents to the north, but the magnitude of these currents should be small; Nantucket Shoals and Georges Bank remove energy from all but the shortest period waves.

No nodal points (location at which the longshore transport changes direction) or fulcrum points (location at which the longshore transport attains a maximum or minimum and no net erosion or accretion occurs) were identified in Eastham for the average yearly wave conditions (Cornillon et al, 1976). The erosion rate in this area predicted by the wave refraction analysis is 13.5 cubic yards per year per foot of shoreline. The eroded material moves south along the Eastham coast. The barrier beach (from Coast Guard Beach to the tip of the north spit at Nauset Harbor inlet) is migrating landward at approximately the same rate at which the cliffs are eroding (Zeigler et al, 1964a). The landward migration process was dramatically demonstrated in February 1978 when Coast Guard Beach was destroyed and extensive washovers were formed along the north spit.

Erosion rates for the scarp area from the Wellfleet-Eastham town line to the north end of Coast Guard Beach are predicted to average about 2 feet per year for the next 50 years (Cornillon et al, 1976), thus producing about 100 feet of shoreline retreat during this time period (Figure 27). Because changes in spits and inlets can occur rapidly and unpredictably, accurate estimates of future shoreline changes in this area cannot be made at the present time.

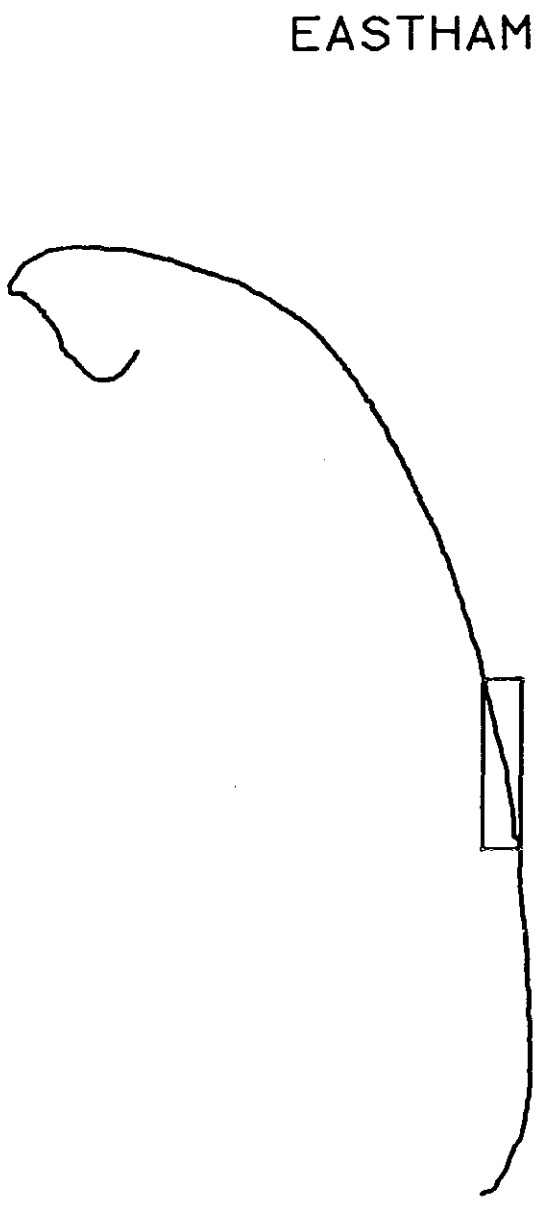


Figure 26. Atlantic coast of Eastham, Massachusetts - location of area shown in Figure 27

EASTHAM

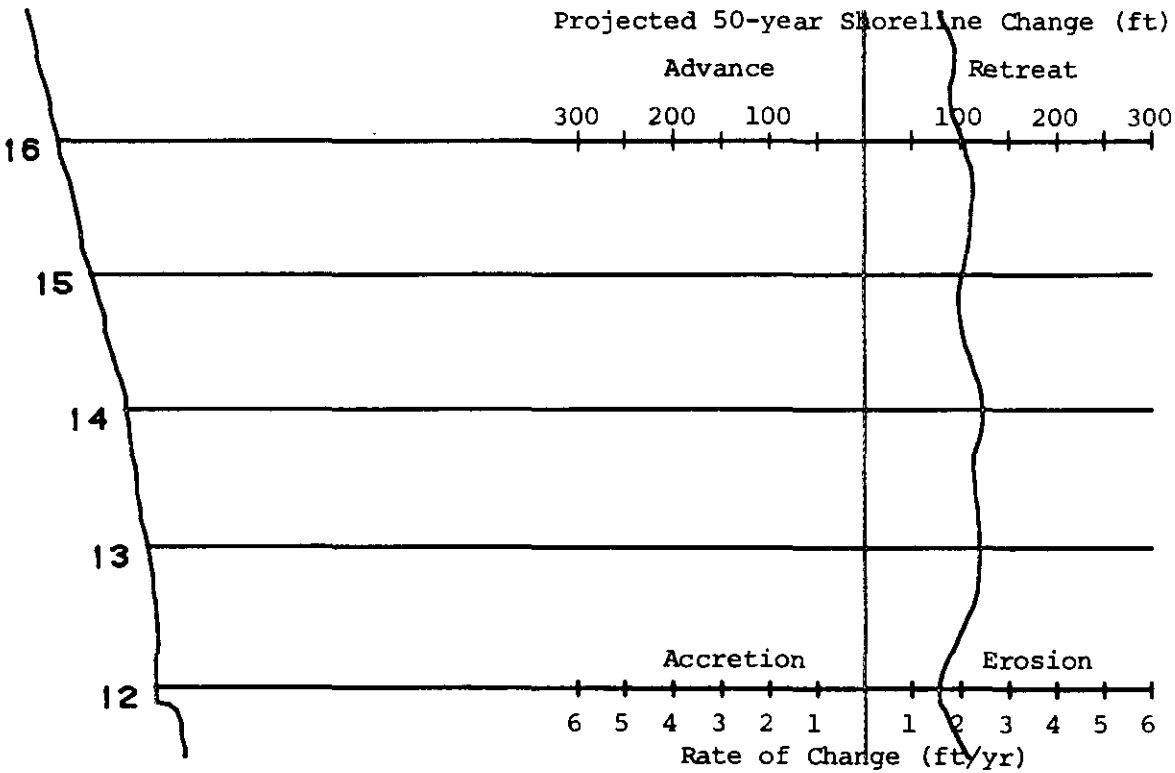


Figure 27. Projected erosion/accretion rates and shoreline changes for the Atlantic coast of Eastham, Massachusetts

METHODS OF CORRECTING

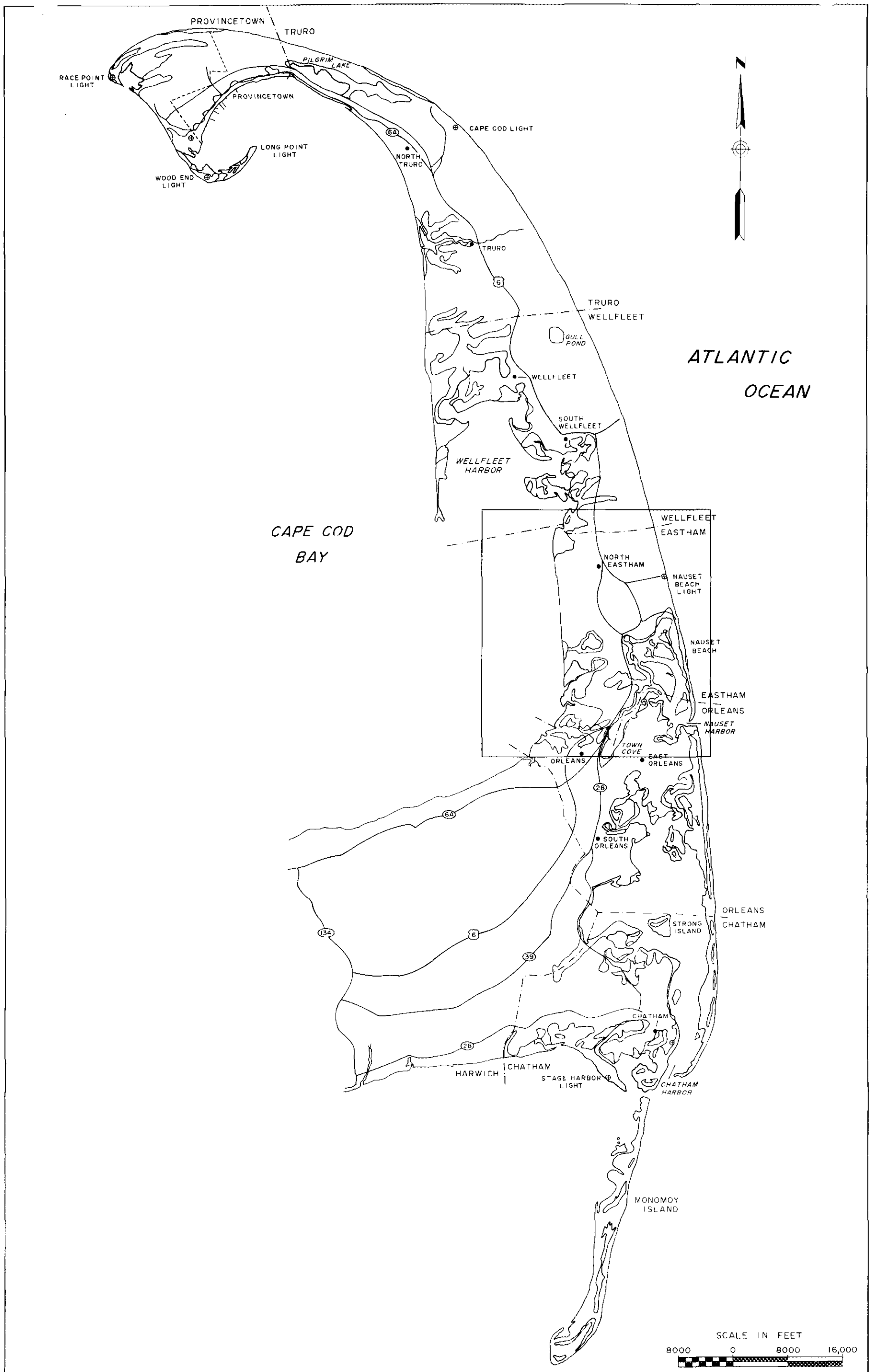
Protective measures that can be employed to protect Cape Cod's Atlantic shore include sand fences, dune grass planting and sand dune use regulations. Several sand fence and dune grass projects have been conducted along Nauset Beach in Eastham, Orleans and Chatham (see Volume II of this report). These projects have successfully rebuilt dunes, although they were subsequently destroyed by storms. The placement of sand fences is relatively inexpensive and takes advantage of the natural processes of sand transport.

Other measures that can be employed to minimize the impact of continued erosion of the shore on the individual landowner include: zoning regulations, building codes, land acquisition for open space needs and buffer zones, and public education and awareness programs. These measures could prevent the construction of high-value buildings in hazardous areas and keep Cape Cod's residents informed of the difficulty and expense of combating natural shore processes.

The last two types of constructive and preventive measures can be employed on Nauset Beach south of Coast Guard Beach. The area is unstable and can be altered significantly by a single storm so that permanent protective structures should not be employed. If structures are allowed, they can be built with a limited life expectancy.

Measures can be taken to maintain or increase the height of the dunes, thus holding much of the available sand in transport. The natural tendency of a barrier beach, such as the North Spit of Nauset Beach, is to migrate landward as wind and waves transport sand to the landward side of the dune. To allow this process to continue rather than to impose structural erosion control measures is to work more in harmony with the forces present on Cape Cod's eastern shore. Vegetative cover on dunes, the face of the scarp and steep banks should be considered as a method of trapping windblown sand. Planting by itself without fertilization will not promote a healthy plant or plants to encourage the more vigorous growth.

This program of dune stabilization and planting should be initiated by the town through the cooperation of the various federal, state and local groups and organizations available in the area. Local conservation groups, dune buggy associations and other concerned organizations can plan planting programs (a guide for the type of plant is included in Volume II of the report). These plantings and educational programs can be established through local boy and girl scout groups, garden clubs and seminars on the local level.

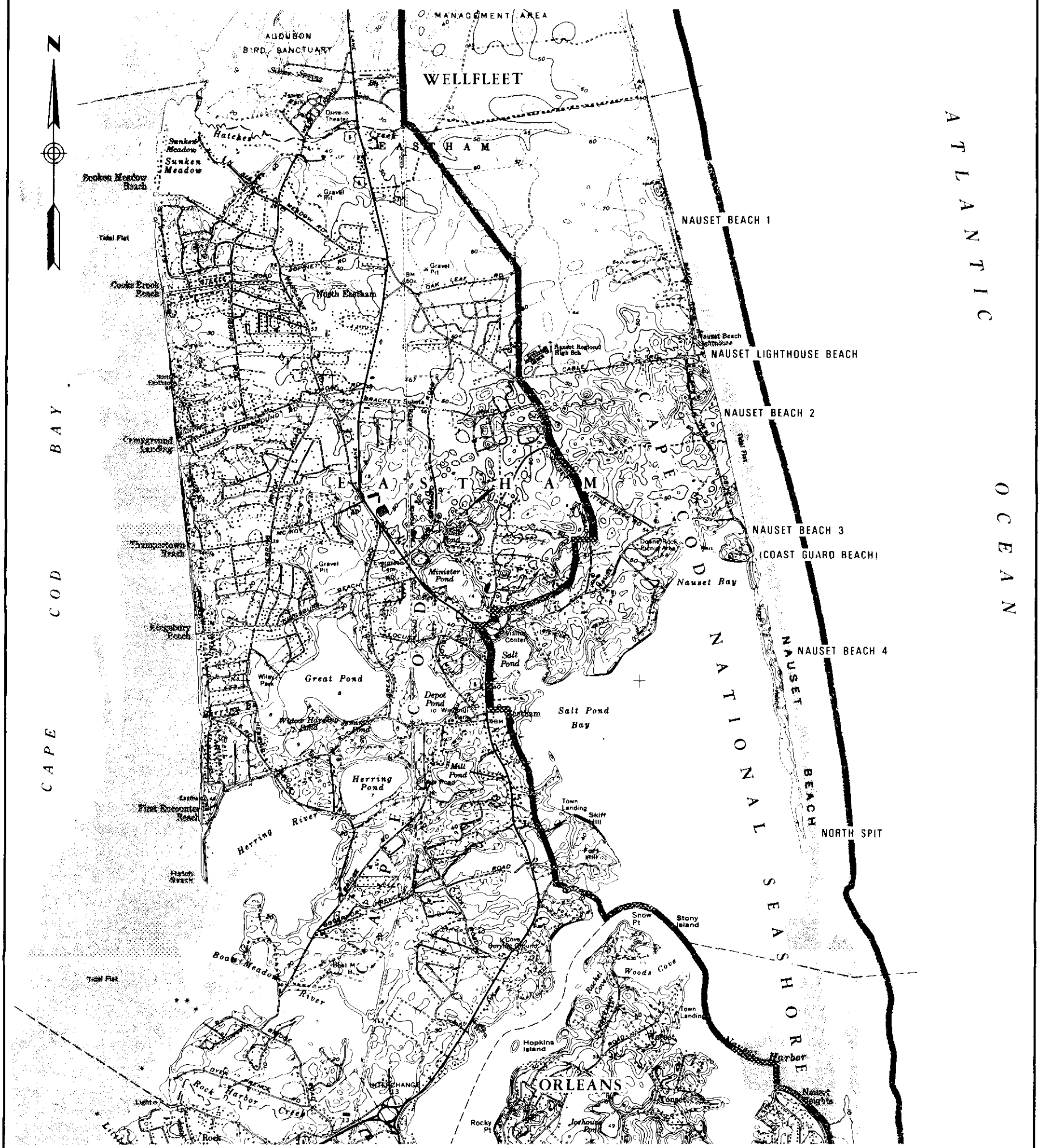


TOWN LOCATION MAP

EASTHAM

BEACH EROSION CONTROL STUDY

CAPE COD EASTERLY SHORES



EASTHAM

BEACH EROSION CONTROL STUDY

CAPE COD EASTERLY SHORES

PLATE D-2

SECTION E

ORLEANS

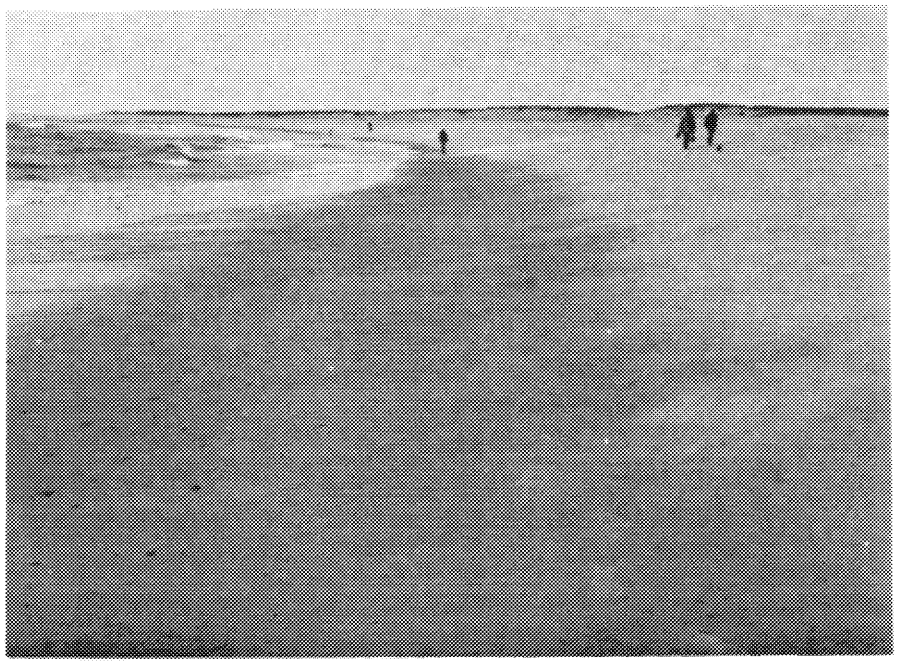


Photo 1. April 1977. Low tide at Nauset Beach, Orleans.

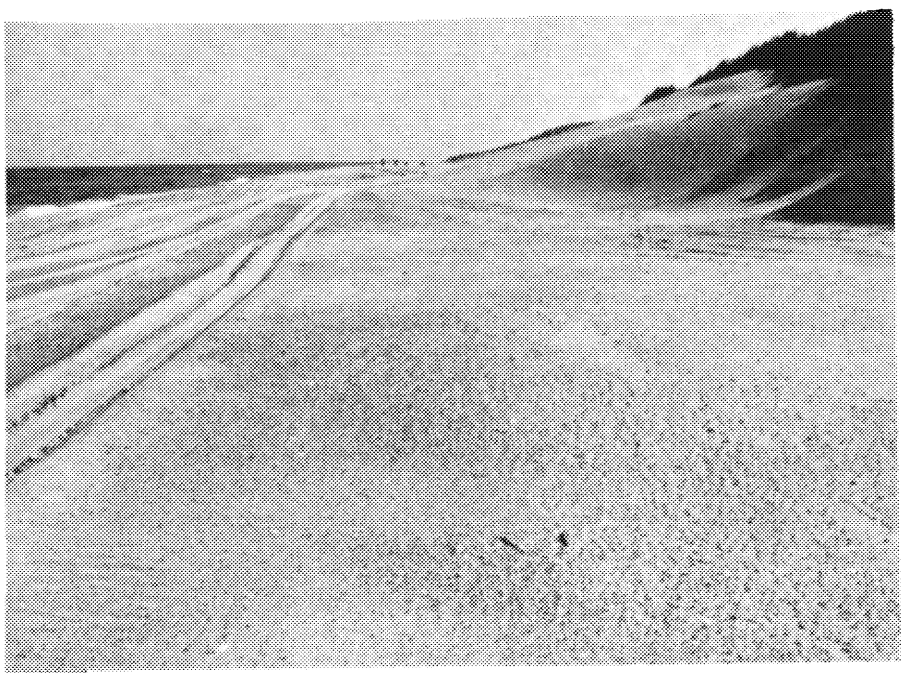


Photo 2. April 1977. The north end of Nauset Beach, Orleans looking to the south. Much of the littoral materials from the upper headlands are deposited as pure white sand along this area.

ORLEANS

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E-1	Orleans Location Map
E-2	Orleans

ORLEANS

GENERAL

Orleans is located on the forearm of Cape Cod (Barnstable Country), Massachusetts (Figure 28). It is bounded by the town of Eastham and Cape Cod Bay on the north, the town of Brewster to its west, the town of Harwich to the southwest, and the town of Chatham to the south. The Atlantic Ocean bounds it on the east. Orleans includes Little Pleasant Bay as well as parts of Pleasant Bay, Town Cove and Nauset Harbor. One-third of the total incorporated area of Orleans is salt water and two-thirds of the remaining area are protected by wetlands restrictions (Massachusetts CZM Program, 1977).

Further information concerning the town of Orleans can be found in the reconnaissance reports for Nauset Harbor, Old Harbor and Chatham (Nauset Beach).

LOCATION AND DESCRIPTION OF BEACHES

Nauset Beach , Orleans

Location - From the Eastham-Orleans town line (near Nauset Harbor inlet) to the Orleans-Chatham town line, including Orleans Town Beach (Figure 29).

Shore Length - Approximately 6 miles.

Ownership - Private, Town of Orleans and U.S. Government, all under the jurisdiction of the Cape Cod National Seashore, National Park Service.

Beach Use - Orleans Town Beach is open to the public for swimming. To the north of Orleans Town Beach, the beach is open to the public even though it is unprotected. The more remote areas such as Nauset Beach below Orleans Town Beach are limited to campers and fishermen with beach buggies. Access to the north spit at Nauset Harbor inlet has been limited by the National Park Service in order to allow the area to recover from the storm of February 1978.

Public Facilities - The only public facilities are located at Orleans Town Beach. They are a bathhouse, refreshment stand and large parking area.

Beach Width - The width of the north and south spits at Nauset Harbor inlet varies from about 200 to 700 feet. Beach width south of the spit varies from

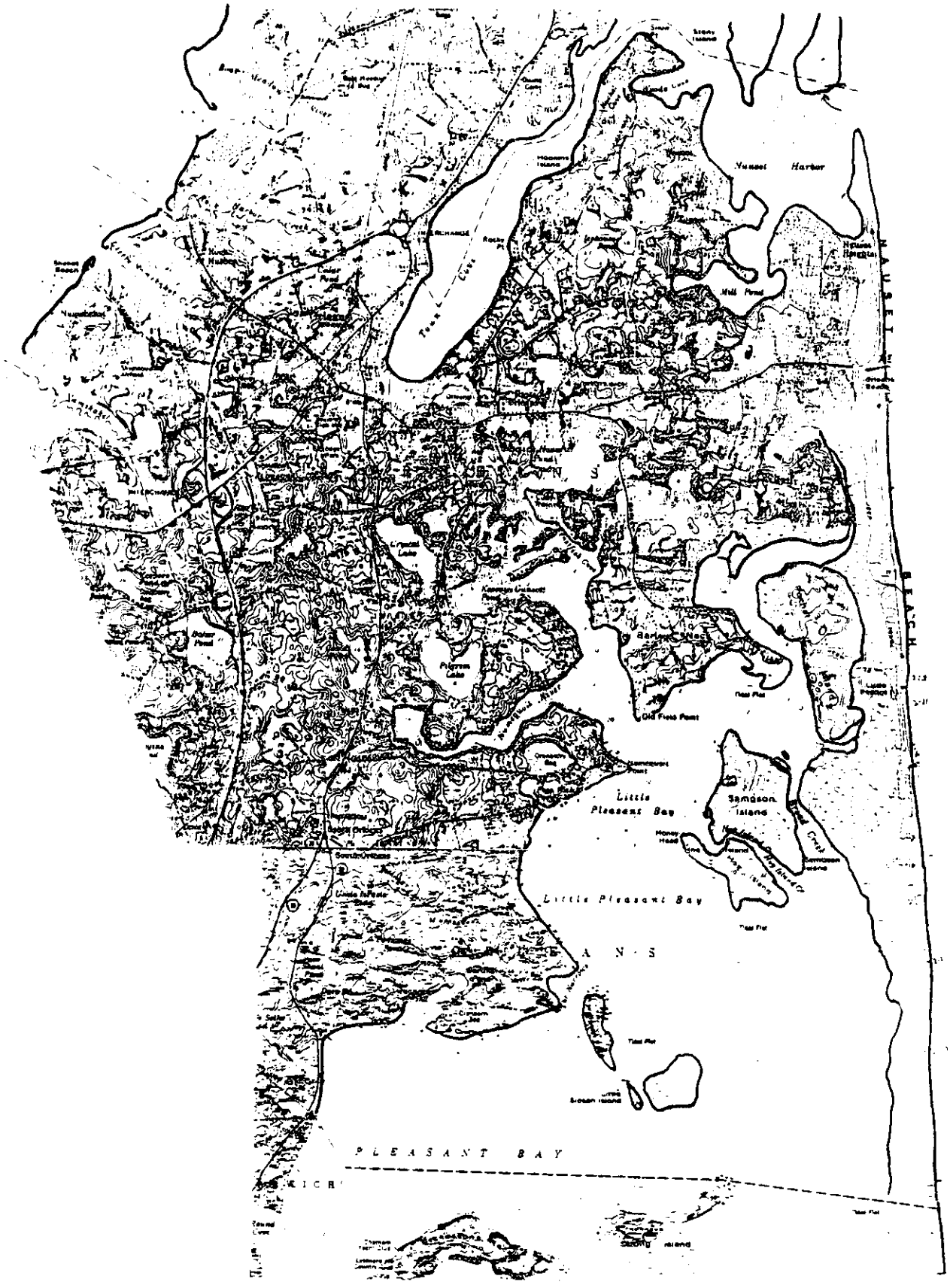


Figure 28. Orleans, Massachusetts

Figure 29. Nauset Beach, Orleans, Massachusetts

50 to 200 feet. On Nauset Spit near the Orleans-Chatham town line, the beach extends on both the east and west sides of the spit which ranges from 500 to more than 1000 feet in width. Actual beach width varies from 10 to 30 feet in winter to greater than 100 feet in summer.

Composition of Shore - Fine beach sand above and below high-water mark. On the spits at Nauset Harbor inlet, dunes are low and overwashing is frequent. Dunes south of the inlet spit area are 10 to 20 feet high and grass covered.

Protective Structures - None; dune building and stabilization efforts have been undertaken on the north and south spits at the inlet to Nauset Harbor.

Shore Structures - Some seasonal cottages are located on Nauset Beach south of Orleans Beach; they are accessible by jeep trail.

Character of Development - There is no significant development along most of the shore and the town facilities are the only structures close to the beach at Orleans Town Beach.

STATEMENT OF THE PROBLEM

Orleans offers many opportunities for water-related activities. Access to both the Nauset Bay area and the Pleasant Bay area is available in Orleans, and boaters in both areas encounter many of the same problems. Navigation channels between the harbors and the Atlantic are constantly shifting, and passage through the inlets is dangerous. Channels within the harbors shoal, and many areas are unusable as anchorages because the depths are so shallow.

SHORE PROCESSES

Wave refraction analysis (Cornillon et al, 1976) predicts that southerly longshore transport will predominate throughout the year along the Orleans coast (Figure 30). The southerly movement is induced primarily by waves from the north through east-northeast. Waves from the east, east-southeast and southeast will produce northerly currents. Northerly longshore currents should also result when waves approach Orleans from the southeast and south, but these cases were not run because of depth constraints in the area of Georges Bank and Nantucket Shoals. Waves approaching from these areas should contribute little to the longshore current because traveling through shallow water removes much of their energy.

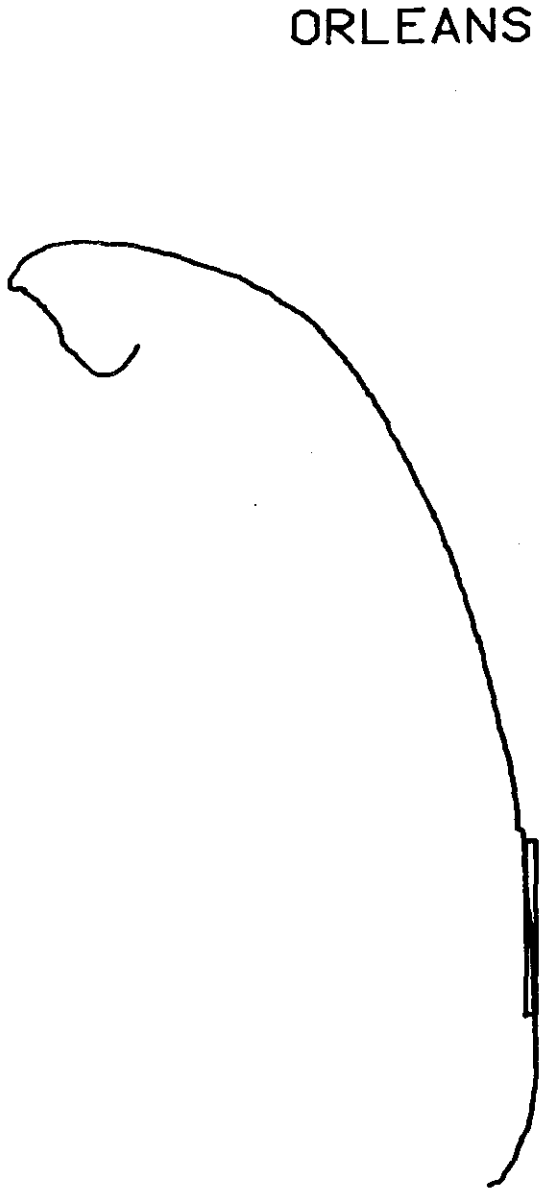


Figure 30. Atlantic coast of Orleans, Massachusetts - location of area shown in Figure 31

No nodal points (location at which the longshore transport changes direction) or fulcrum points (location at which the longshore transport attains a maximum or minimum and no net erosion or accretion occurs) are predicted for Orleans by the wave refraction analysis. The predicted sediment transport rate along this section of the coast is 675,000 cubic yards per year to the south.

Wave refraction analysis predicts little erosion south of the 10-mile mark. In fact, slight amounts of accretion are indicated in this area (Figure 31). However, accretion is not anticipated on this section of Nauset Beach. Landward migration of the barrier beach should result in shoreline retreat rather than advance for the foreseeable future. (The amount of accretion predicted is within the limits of accuracy of the analysis and may result at least in part from the omission of waves approaching Orleans from the south and southeast.) At this time, accurate erosion/accretion rates cannot be predicted for the barrier beach system, particularly in areas such as the spits at Nauset Harbor inlet where complex inlet dynamics can produce changes in the inlet with every tide.

METHODS OF CORRECTING THE PROBLEM

Three erosion problems are encountered on Orleans' Atlantic coast: migration of the spits and inlet at the entrance to Nauset Harbor, erosion in the area of Orleans Town Beach and landward migration of the barrier beach south of the town beach.

Stabilization of the inlet to Nauset Harbor is desired by the local citizenry but is too costly to be justifiable (U.S. Army Corps of Engineers, 1969). Any plan to stabilize the inlet by structural means would interfere with the natural process of inlet migration which causes the inlet to move north and south and might in time cause a new inlet to form, for example, at Coast Guard Beach. If natural processes favored closure of an existing inlet and the formation of a new one, attempts to stabilize the existing inlet could be even more costly than anticipated.

Spit migration landward complicates any plans to stabilize either the inlet or the spit. An experiment testing the sand trapping ability of sand fence and beach grass on the south spit was successful in building and stabilizing sand dunes. Such efforts, if successful, may temporarily slow the natural process, but they will not be successful in stopping or reversing the erosion because the area is so dynamic. This was demonstrated when the experiment, originally started on the north spit, had to be abandoned because much of it was destroyed. The frequency of replacement can make this solution costly.

ORLEANS

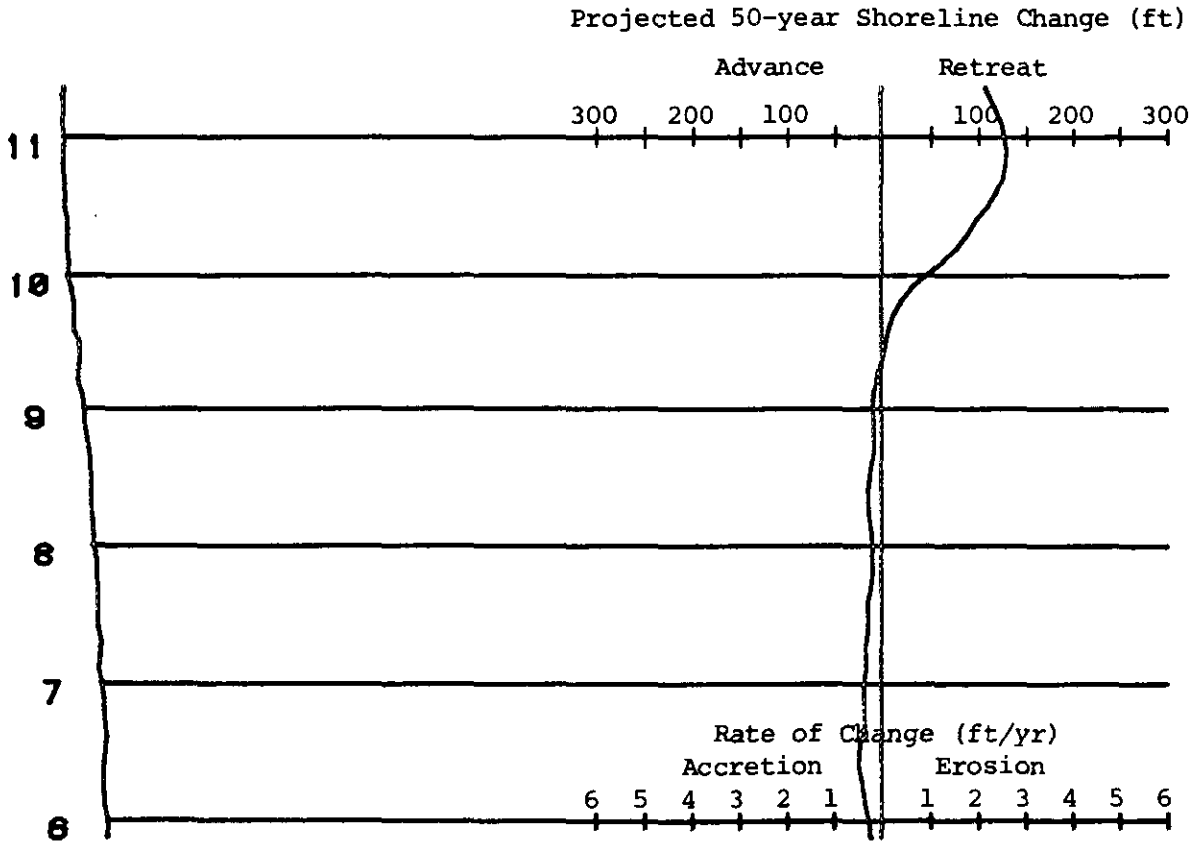


Figure 31. Projected erosion/accretion rates and shoreline changes for the Atlantic coast of Orleans, Massachusetts

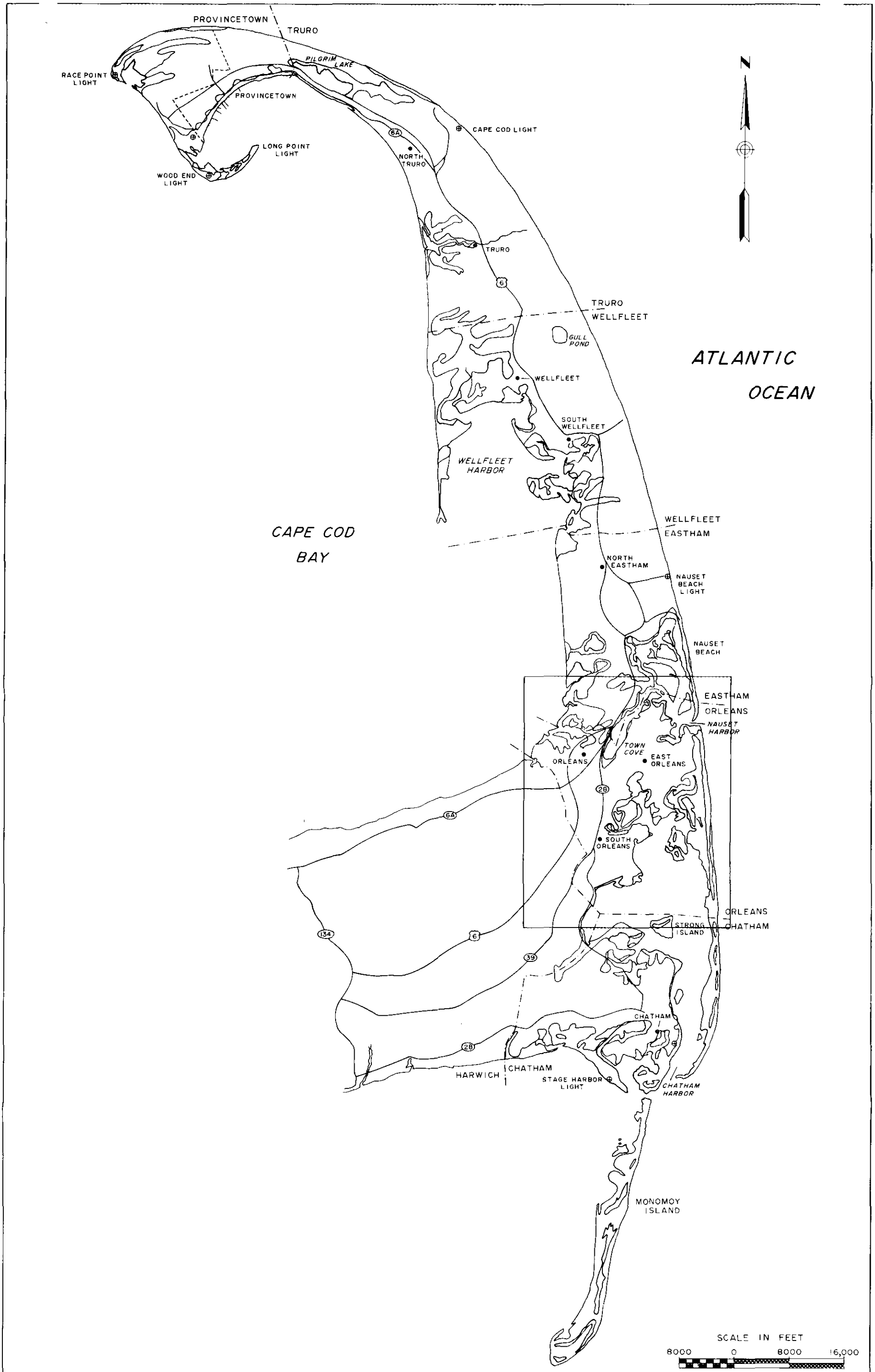
If maintenance of navigation channels behind the spit is dependent on the integrity of the spit, sand fencing and grass planting can slow the transport of sand across the beach. This could reduce eolian transport from the beach into the area behind the spit. If sand fencing and beach grass planting are implemented or if dune growth is to be encouraged in any areas where incipient dunes exist, ORVs and pedestrians must be kept out of the project areas. Traffic can damage or destroy new or existing vegetation as well as erode washovers and encourage their continued existence.

Traffic control has been implemented successfully at Orleans Town Beach, where fencing is used to prevent beach access over the dunes and boardwalks are provided to accommodate the heavy foot traffic. Access to a jeep trail is also provided at the town beach.

Better control of off-the-road vehicles is needed in areas away from the Town Beach. Indiscriminant driving has killed some vegetation in the area east of Nauset Heights, and south of Orleans Town Beach, ORV tracks are visible both on the dunes and in the marshes. Driving off established trails into dunes and marshes is prohibited, but the prohibition is difficult to enforce. Education and information programs stressing the importance of vegetation are needed. Even one pass by an ORV can cause significant damage, depending on the type of vegetation involved (Godfrey, 1978).

In some areas, several parallel ORV trails are located close together. Unnecessary trails should be closed and vegetation planted or encouraged. Washover areas along Nauset Beach should be fenced to stop ORV traffic through the washover. (This has been accomplished at several locations.) Such traffic perpetuates the washover and inhibits any natural healing of the area. Marked crossovers from the beach to the jeep trail should be designated and designed to discourage formation of washovers or blowouts.

None of the measures suggested in this section will prevent the inevitable erosion, but wise use of the beach may prevent accelerated erosion. Additional ramps to and from parking areas to direct foot traffic, preserve backshore dunes and encourage vegetation and dune build-up will result in a rapid growth of the backshore dunes.

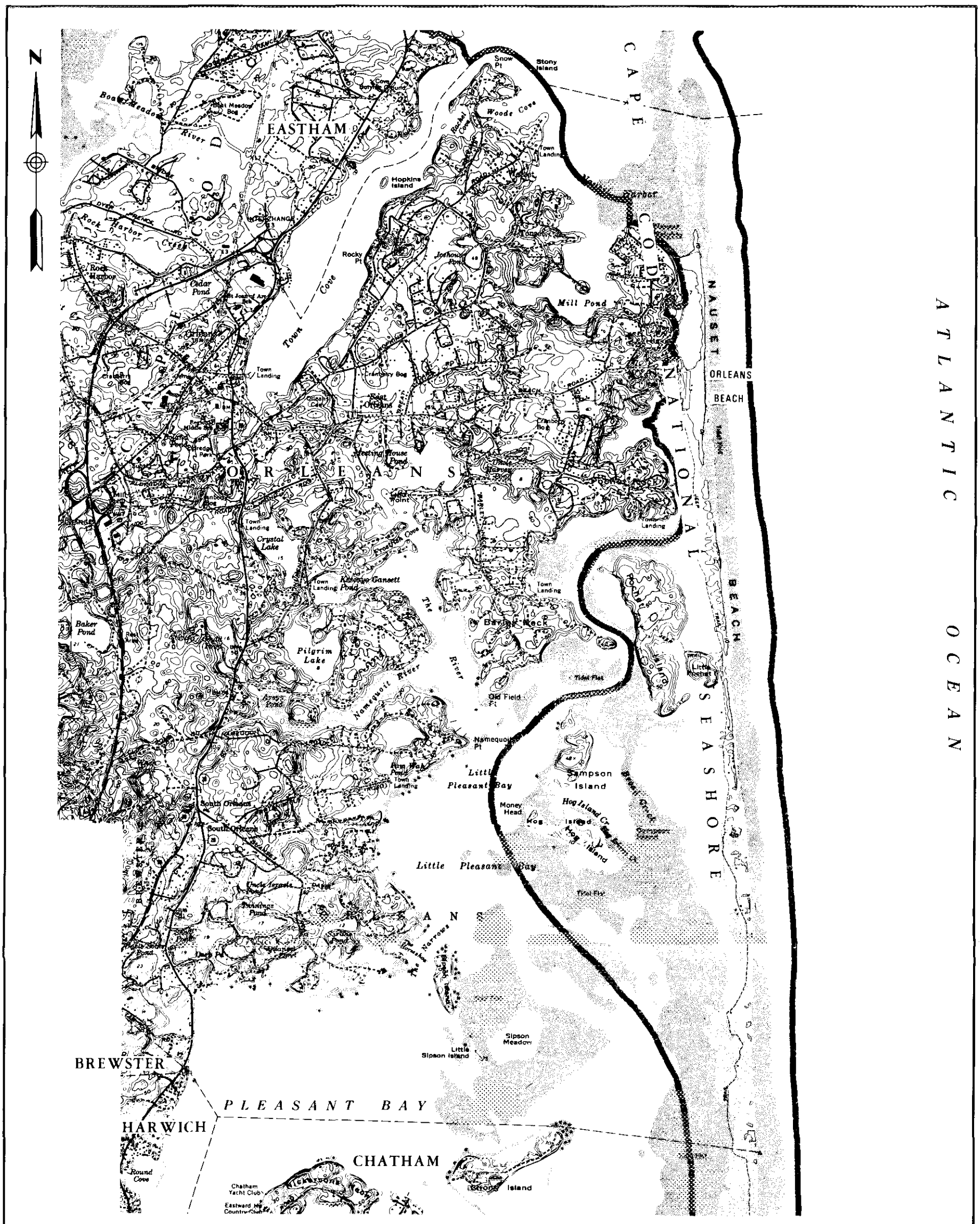


TOWN LOCATION MAP

ORLEANS

BEACH EROSION CONTROL STUDY

CAPE COD EASTERLY SHORES



ORLEANS

BEACH EROSION CONTROL STUDY

CAPE COD EASTERLY SHORES

PLATE E-2

SECTION F

CHATHAM

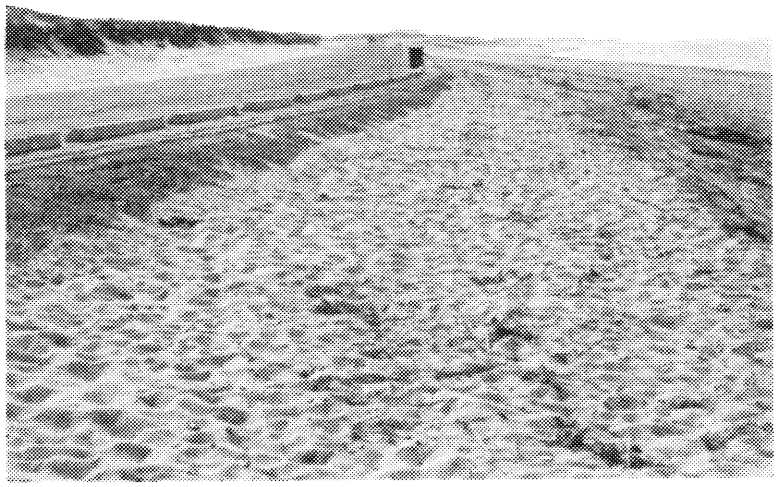


Photo 1. January 1967. The effect of sand fences in dune building is easily seen in this aesthic view of southern Nauset Beach, Chatham. The now removed Old Harbor Coast Guard Station looms in background.

Photo 2. April 1977. The sandy southern tip of Nauset Beach, Chatham looking due east.

CHATHAM

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PLATES

No.	Title
F-1	Chatham Location Map
F-2	Chatham

CHATHAM

GENERAL

Chatham (Figure 32) is located in the southeastern section of Cape Cod (Barnstable County), Massachusetts. It is bounded on the north by the town of Orleans, on the west by the town of Harwich, on the south by Nantucket Sound and the Atlantic Ocean and on the east by the Atlantic Ocean. Chatham includes Chatham Harbor, Aunt Lydia's Cove, Bassing Harbor, Crows Pond, Ryder Cove and parts of Pleasant Bay. Nauset Beach forms the easternmost boundary of Chatham and is part of the Cape Cod National Seashore.

LOCATION AND DESCRIPTION OF BEACHES

Nauset Beach, Chatham

Location - From the Orleans-Chatham town line to the southern end of the spit (Figure 33).

Shore Length - 5.8 miles.

Ownership - Private, town of Chatham and U.S. Government, all under the jurisdiction of the Cape Cod National Seashore, National Park Service.

Beach Use - Limited to campers and fishermen with beach buggies.

Public Facilities - None; beach is open to the public but is accessible only by beach buggy or boat.

Beach Width - Beach extends on both east and west sides of the spit, which ranges from 500 to 3200 feet in width. Actual beach width varies from 10 to 30 feet in winter to 130 to 180 feet in summer.

Composition of Shore - Fine beach sand above and below high water. Grass-covered dunes 10 to 20 feet high occur on the northern section; the dunes decrease in height toward the south, and dunes give way to a broad flat sand spit toward the end of the beach.

Protective Structures - No permanent structures; several attempts have been made to build or stabilize dunes using beach grass, sand fence and discarded Christmas trees. (Further information on dune building projects is available in Volume II of this report.)

Figure 32. Chatham, Massachusetts

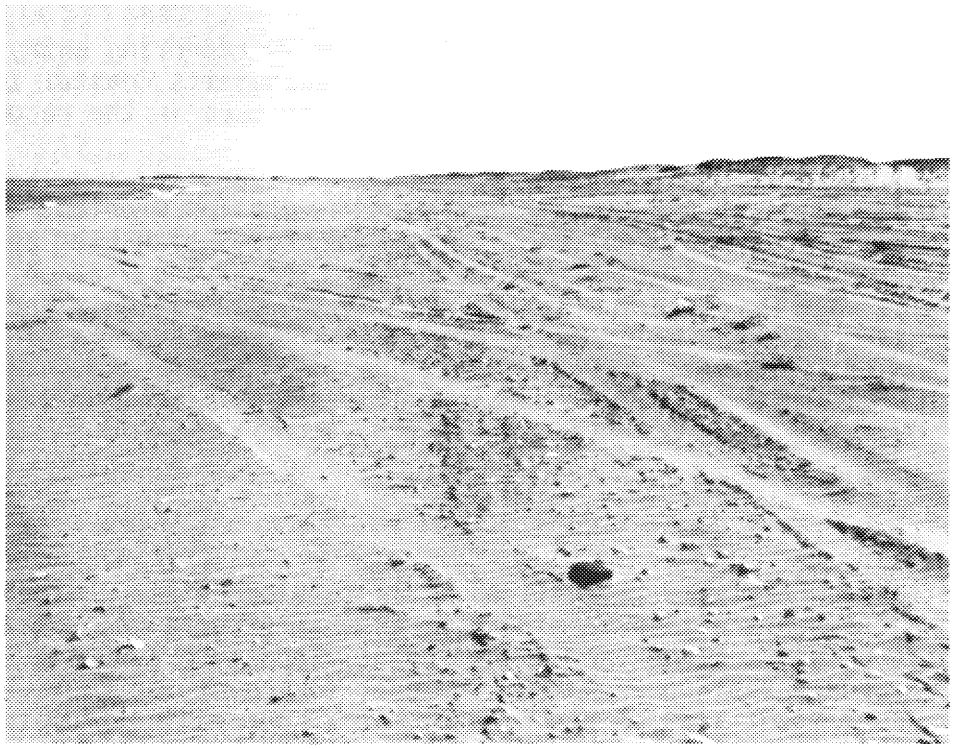


Figure 33. Nauset Beach, Chatham, Massachusetts

Shore Structures - Seasonal cottages are located to the north and south of the Old Harbor Life Saving Station site.

Character of Development - The entire shoreline is open to the public for swimming and fishing. There are several seasonal cottages on privately owned properties. The beach is used extensively during the summer by fishermen with beach buggies.

STATEMENT OF THE PROBLEM

The number one priority of the town of Chatham is improving entry into Chatham Harbor and Pleasant Bay, according to the Massachusetts Coastal Zone Management (CZM) Program (1977). This concern is addressed in the reconnaissance report for Old Harbor.

Landward migration of the barrier beach causes erosion problems on the outer shores and encroachment problems on the inner shores of Nauset Beach. Erosion problems were evident at the Old Harbor Life Saving Station which had to be moved when waves were breaking against its foundation. Encroachment problems involve shoaling of navigation channels and covering of valuable shellfish beds.

SHORE PROCESSES

Wave refraction analysis (Cornillon et al, 1976) predicts that southerly longshore transport will predominate at Chatham (Figure 34). Although southerly drift prevails along the Chatham coast, longshore currents to the north can occur when waves approach from the east-southeast and southwest. Northerly currents might also be produced by waves approaching from the south-southeast and south, but these cases were not run because of insufficient depth information. The magnitude of currents produced by waves from the southeast quadrant should be relatively small due to the attenuating effect of Georges Bank and Nantucket Shoal.

No nodal points (location at which the longshore transport changes direction) were identified in Chatham; however, a fulcrum point was identified at the 1-mile mark. (A fulcrum point is the location at which the longshore transport attains a maximum or minimum, and no net erosion or accretion occurs.) The maximum predicted sediment transport rate is to the south of the 1-mile mark and is approximately 5.25 million cubic yards per year. High rates of accretion should occur south of this point while erosion will predominate north of this point.

Erosion rates of 1 to 5 feet per year are predicted for the Chatham coast (Figure 35). However, these rates are subject to large inaccuracies due to the intrinsic instability of the barrier beach system. Continued landward migration of the barrier beach is anticipated in this area, but the amount of shoreline retreat cannot be predicted accurately.

CHATHAM

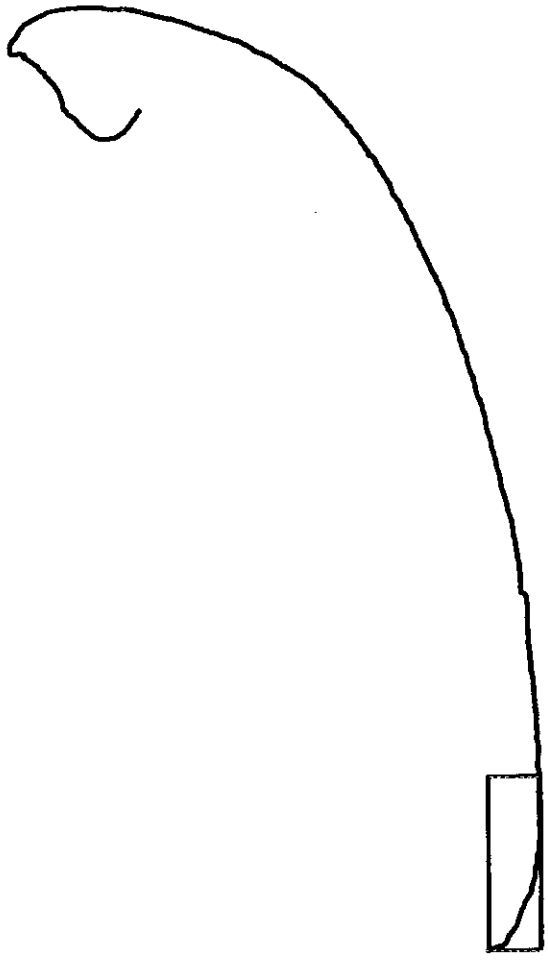


Figure 34. Atlantic coast of Chatham, Massachusetts - location of area shown in Figure 35

CHATHAM

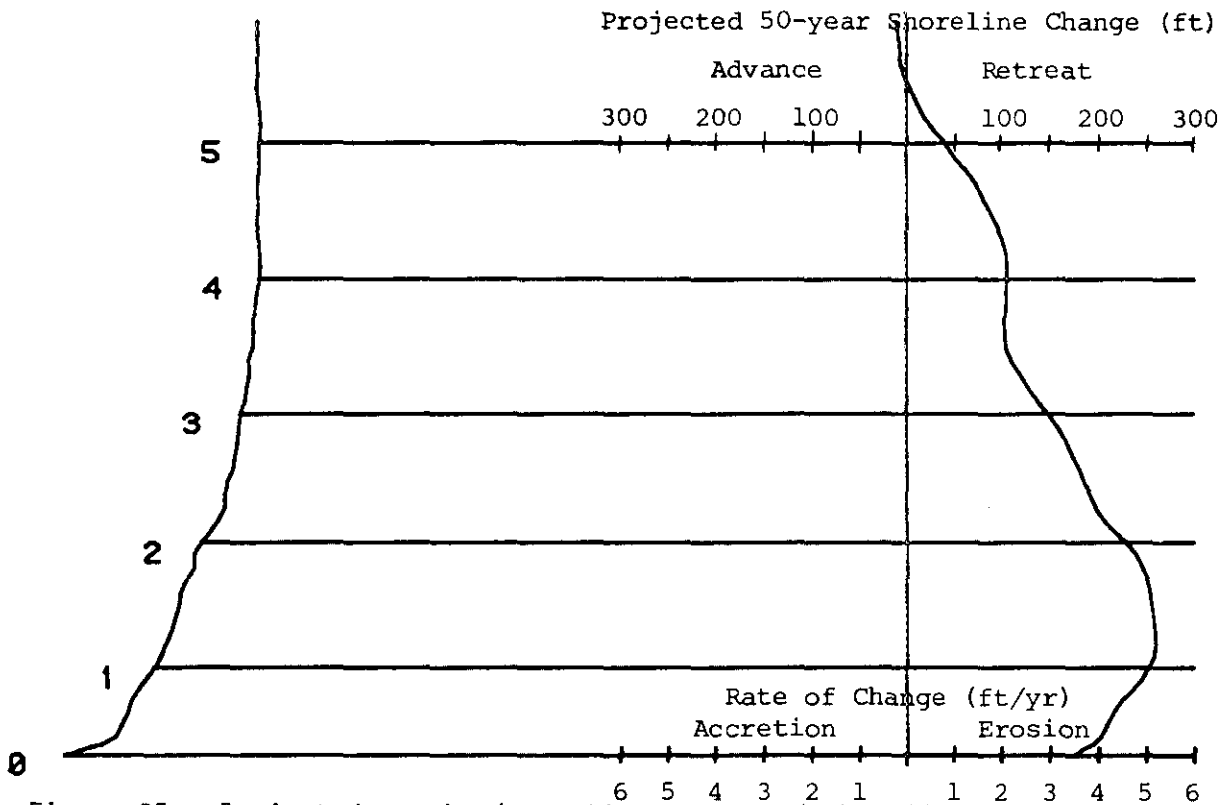


Figure 35. Projected erosion/accretion rates and shoreline changes for the Atlantic coast of Chatham, Massachusetts

METHODS OF CORRECTING THE PROBLEM

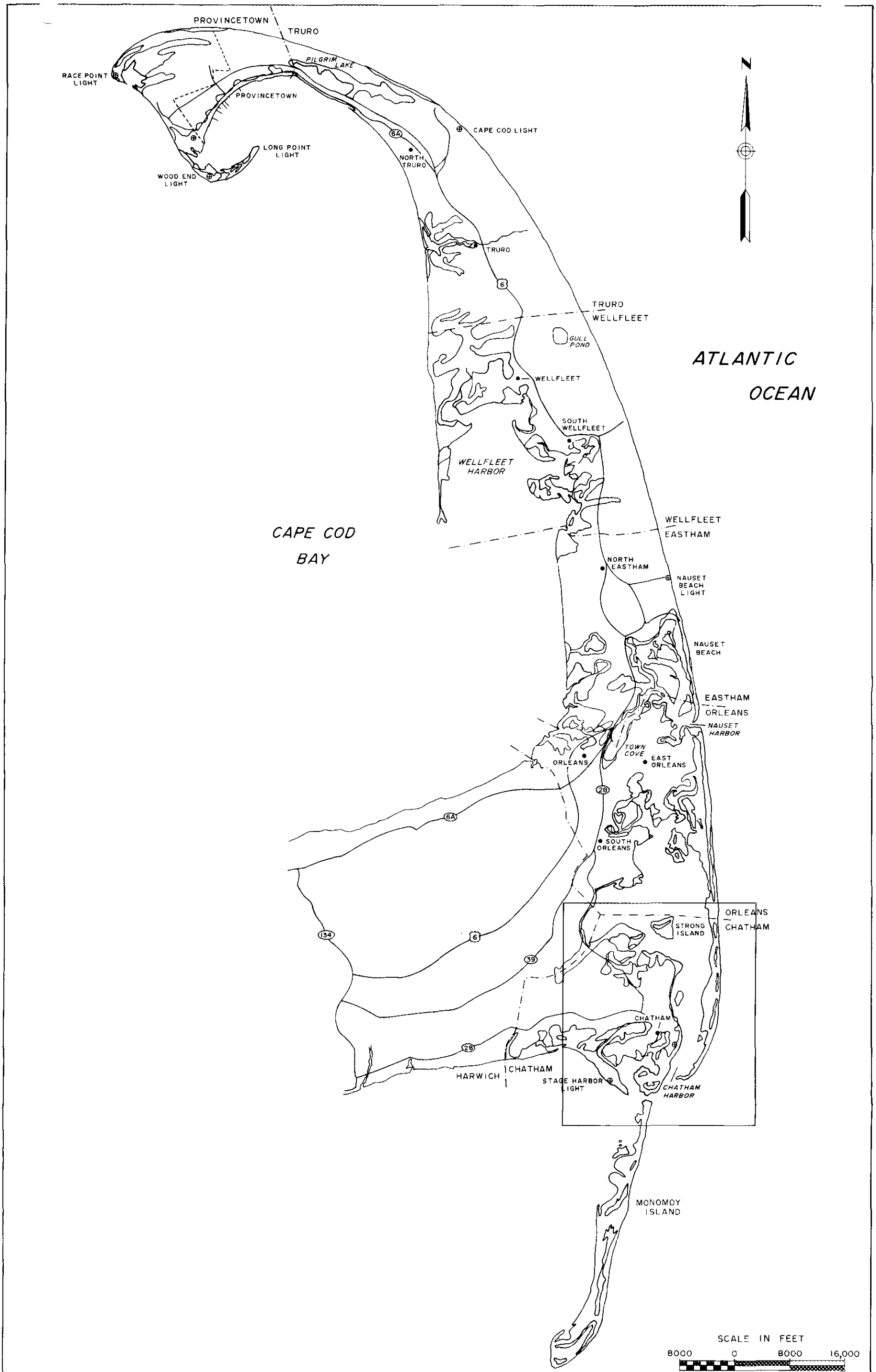
Due to the nature of barrier beaches, it is not feasible to attempt to stabilize the barrier:

> . . .one principal way that a barrier responds to stress conditions is by change -- erosion and accretion. During storms large waves coupled with a high storm surge may overtop and erode the dunes as overwash, depositing new sand on the barrier flats, marsh or into the bay. The islands are not being "washed away" by this process, but instead are naturally retreating under the conditions of gradually rising sea level. . . .
>
> The engineering approach of trying to impose stability on a naturally unstable environment need not be applied. In actuality, the question is not, can engineering work be used to hold the shoreline in place, but rather should such an approach be employed? The natural stability of the barrier system is derived from its ability to shift, change or bend in response to the physical forces. (Leatherman, Godfrey and Buckley, 1978)

If no action is taken to interfere with the natural process, Nauset Beach will most likely continue to migrate landward. The inlet to Chatham Harbor may change its location, as it has done in the past, and a new inlet may be formed. Structures located on the barrier spit will eventually be threatened by erosion and will have to be moved. In extreme cases, buildings may be destroyed by storms.

In the past, efforts at dune building and stabilization have succeeded in temporarily preventing washovers, particularly in the area of the Old Harbor Life Saving Station site. Stabilizing all of the washovers along Nauset Beach would be a formidable task as washovers have amounted to as much as 3 miles of the 8-mile long spit. In addition, dune building requires more than just an initial effort, grasses need fertilization, fences need mending and, periodically, large sections of the project may be destroyed. Dune building must be viewed as a temporary interruption of the continuing process of barrier beach migration.

The Town of Chatham has expressed concern that ecologic damage is being caused by foot and vehicular traffic on the beach (Massachusetts CZM Program, 1977). CZM has recommended that the town restrict the number of cars allowed on the beach, construct barriers (such as snow fences) around dunes to discourage vehicles from driving on them and regulate foot traffic so that paths will not create cuts in the beach (Massachusetts CZM Plan, 1977). See Volume II Appendix 2 for suggested improvements in the area.

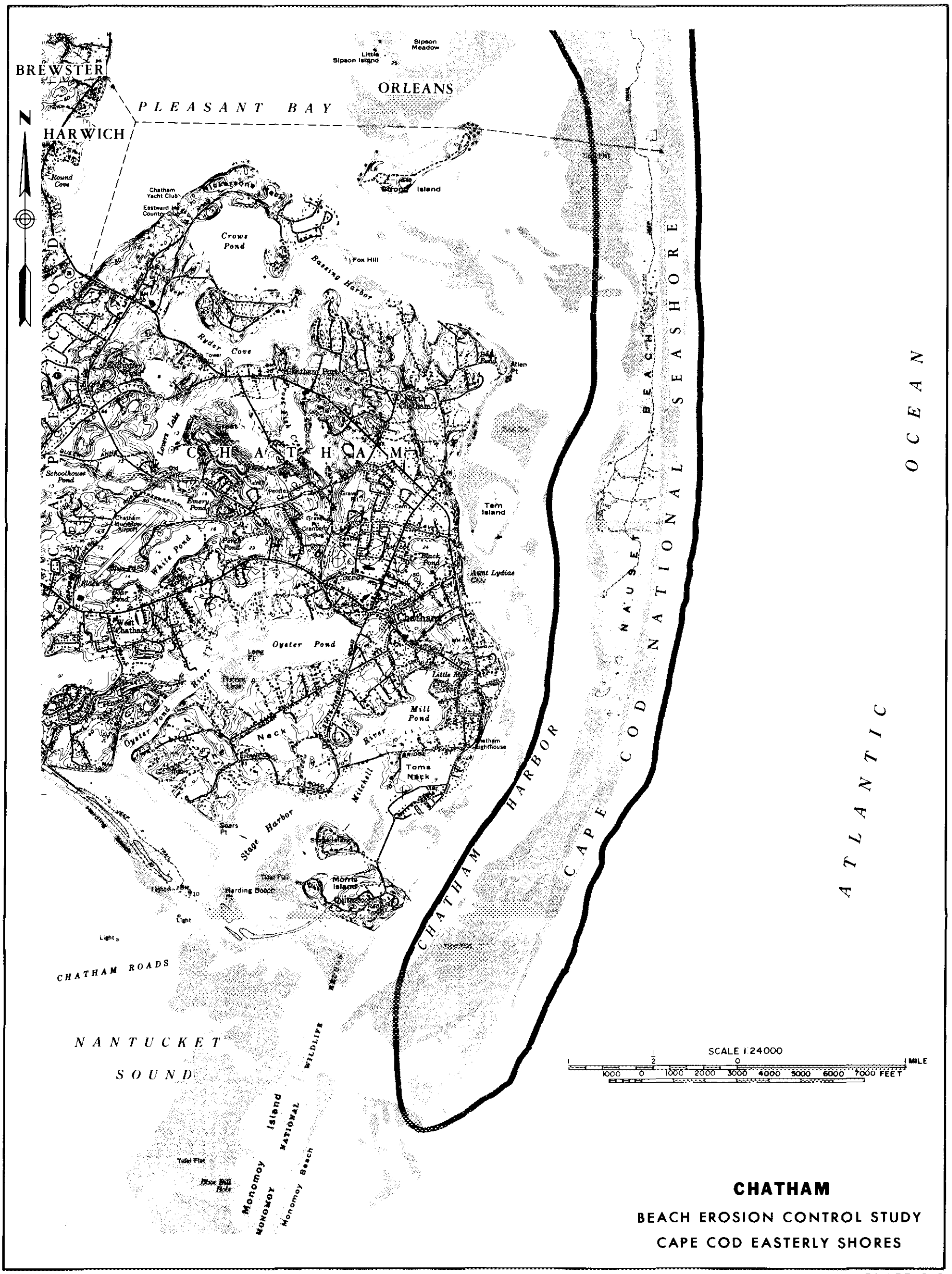


TOWN LOCATION MAP

CHATHAM

BEACH EROSION CONTROL STUDY

CAPE COD EASTERLY SHORES



CHATHAM

BEACH EROSION CONTROL STUDY

CAPE COD EASTERLY SHORES

PLATE F-2

SECTION G

NATIONAL PARK SERVICE

CAPE COD NATIONAL SEASHORE

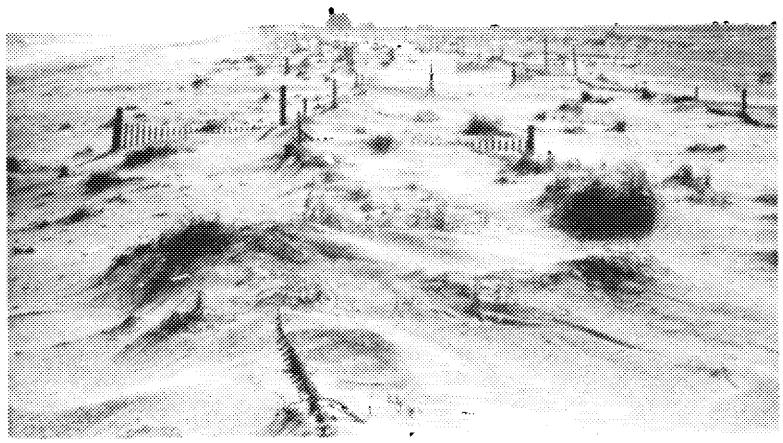


Photo 1 . April 1977. A view to the southwest from northern Herring Cove Beach, Provincetown.

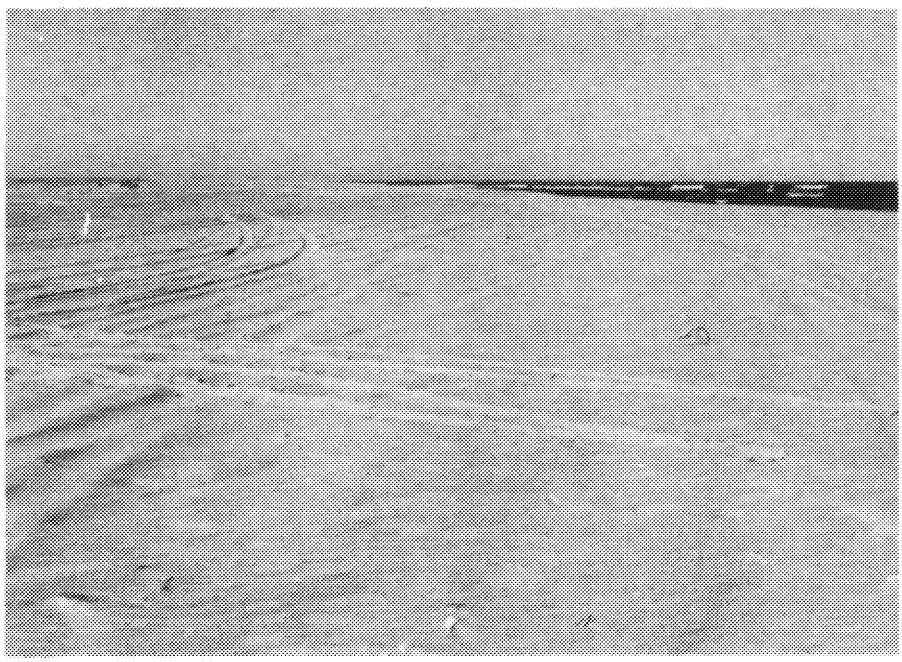


Photo 2 . November 1977. Herring Cove Beach seen from the roadway looking towards the north.

Photo 3. Race Point looking north, 21 October 1964.

Photo 4 . November 1977. A shot taken near the Coast Guard Station at Race Point Beach, Provincetown looking to the northeast. Note dune formation behind sand fence.

Photo 5 . April 1977. Eastern end of Race Point Beach with a view to the west. Coast Guard Station shown at left.

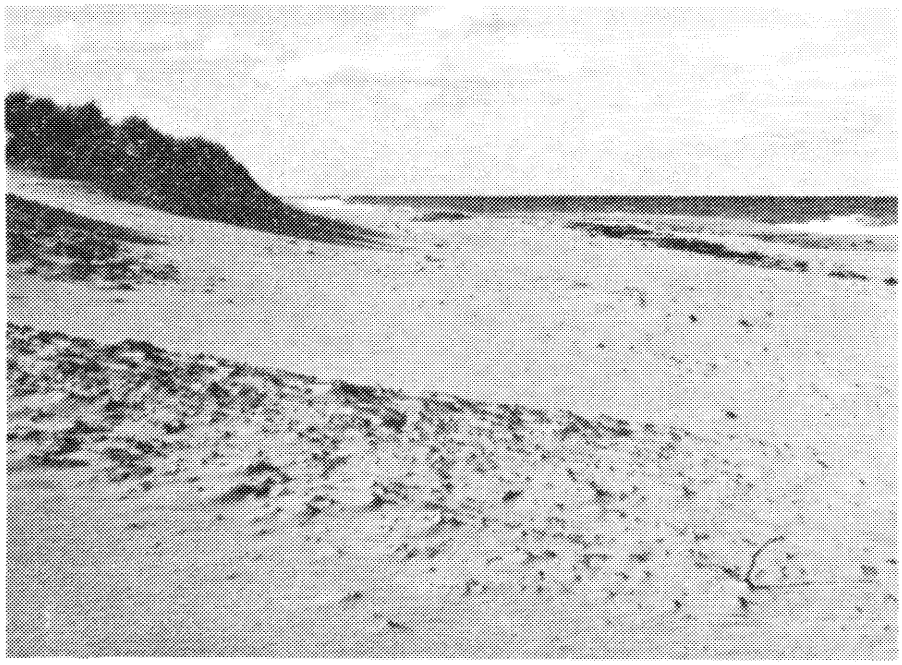


Photo 6. November 1977. A scenic view to the northwest at high tide on Head of the Meadows Beach, Truro.

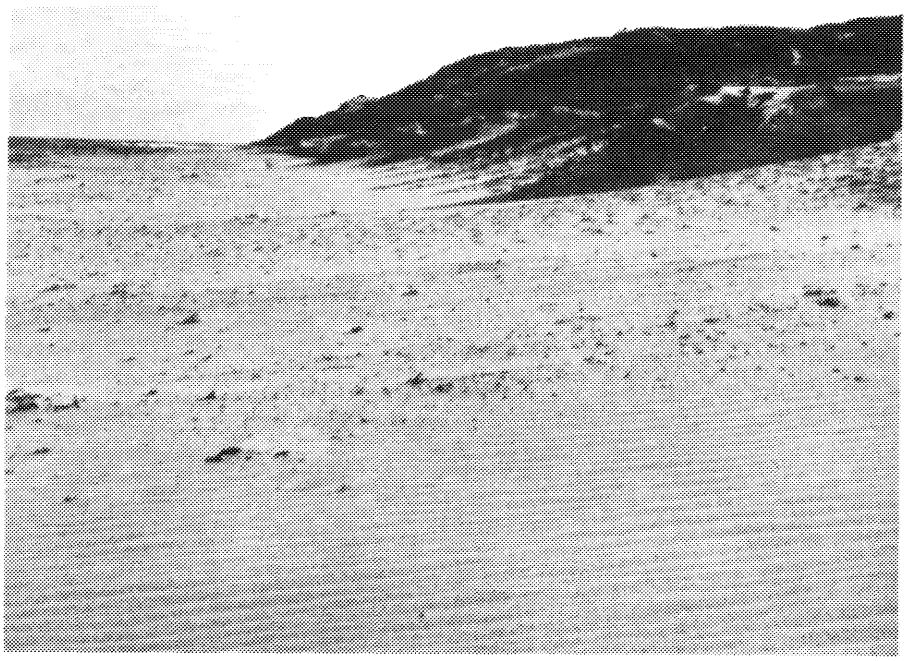


Photo 7. November 1977. Looking southeast on Head of the Meadows Beach.

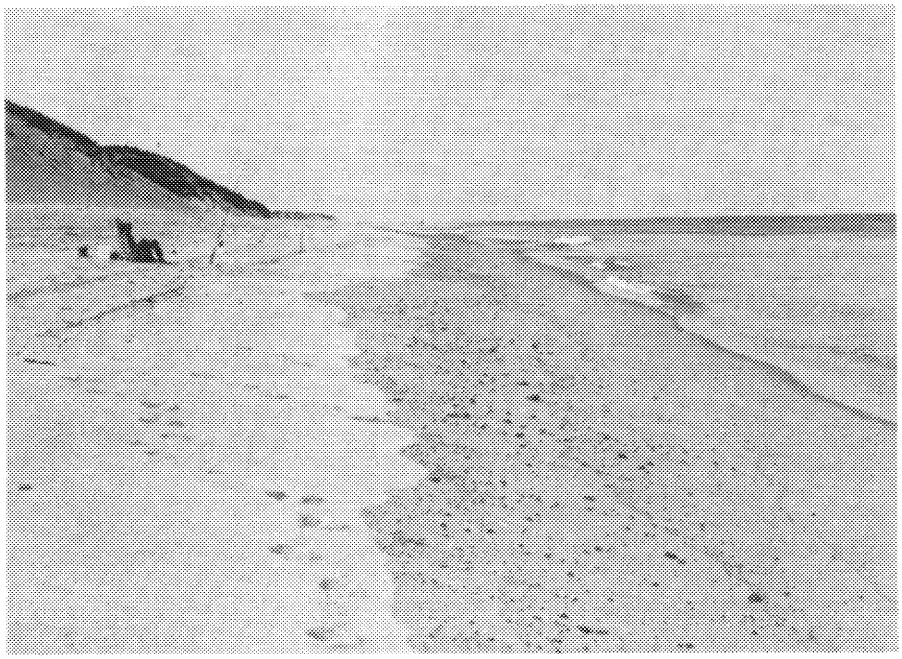


Photo 8 . April 1977. A lazy springtime afternoon on Highland Beach, Truro.

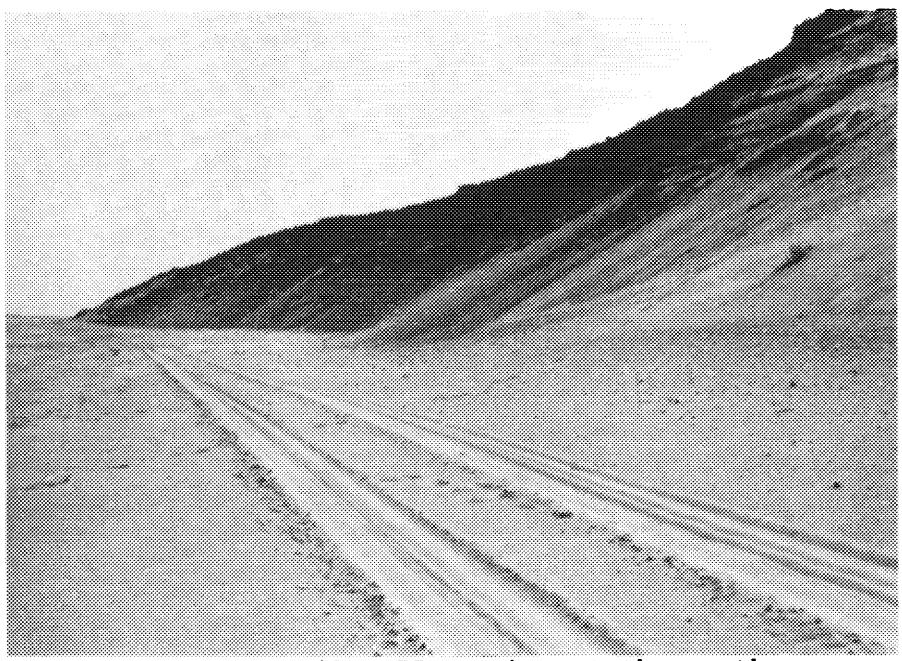


Photo 9 . April 1977. Taken at the northern extreme of Marconi Beach, Wellfleet. This picture indicates endless pristine beauty present along the outer Cape.

Photo 10. November 1977. A view to the south from the Marconi site looking toward Marconi

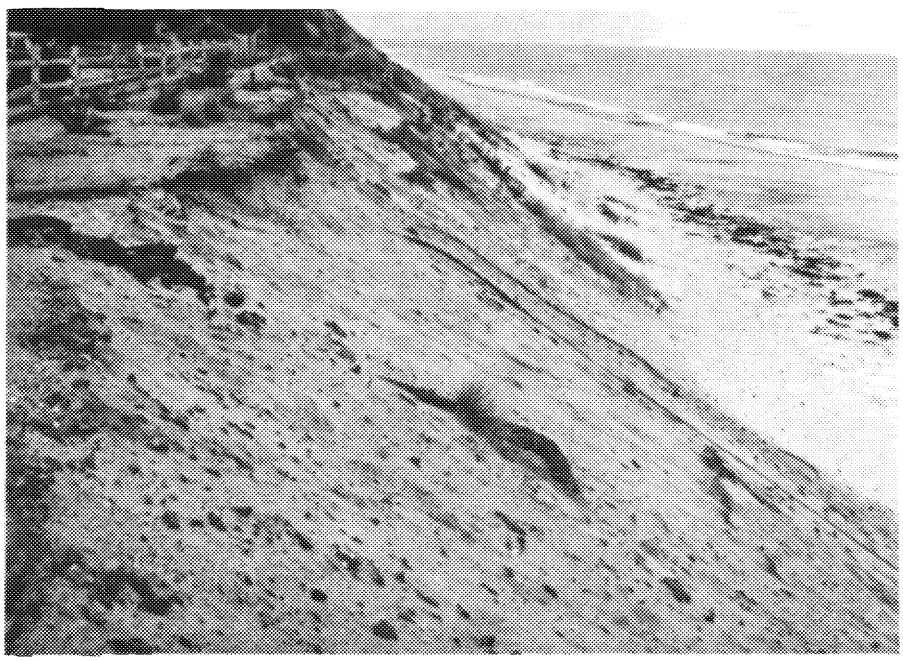


Photo 11. November 1977. A look down the scarp onto Nauset Light Beach from the parking area.

Photo 12. April 1977. Erosion at Coast Guard Beach, Eastham looking to the south.

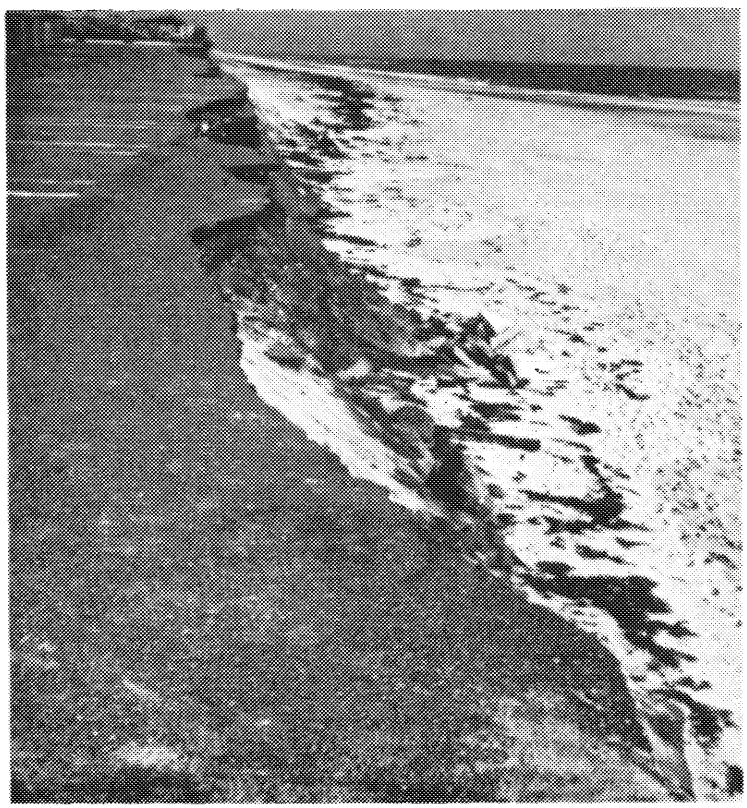


Photo 13. November 1977. Deteriorating parking area at Coast Guard Beach, note normal high tide line in the sand. w

NATIONAL PARK SERVICE

CAPE COD NATIONAL SEASHORE

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No.	Title
G-1	Location of Beaches

NATIONAL PARK SERVICE CAPE COD NATIONAL SEASHORE

POLICY AND BOUNDARY

Cape Cod National Seashore (Figure 36) encompasses the Atlantic coast of Cape Cod from Provincetown to Chatham. Established by an Act of Congress on 7 August 1961, the Seashore is administered by the National Park Service (NPS), U.S. Department of the Interior. Its purpose is summarized in NPS literature:

> Until recently, Cape Cod's natural and historic scene was preserved by individuals, the towns, and the Commonwealth. The establishment of Cape Cod National Seashore in 1961 now more permanently assures this protection. Beach, heath, forests and ponds are no longer threatened in one of the last expanses of uninterrupted natural lands along the Atlantic.

The Act establishing the Cape Cod National Seashore specified preservation as the primary goal:

> In order that the seashore shall be permanently preserved in its present state, no development or plan for the convenience of visitors shall be undertaken therein which would be incompatible with the preservation of the unique flora and fauna or the physiographic conditions now prevailing...

However, the enabling legislation for the Seashore does allow the Secretary to

> ...provide for the public enjoyment and understanding of the unique natural, historic and scientific features of Cape Cod within the seashore by establishing such trails, observation points, and exhibits and providing such services as he may deem desirable for such public enjoyment and understanding (Public Law 87-126).

A total of 44,600 acres are contained within the National Seashore bounds (Table 1). Of these, 29,900 will ultimately be acquired. The remainder is not subject to acquisition according to the legislation that created the Seashore. Included within its boundaries are natural environment areas as well as land developed for recreation (Table 2).

One-third of the Nation's populace lives within a day's drive to Cape Cod, and the Seashore attracts millions of visitors annually. The number of visits increased from almost two million in 1964 to more than five million in 1976 (Table 3).

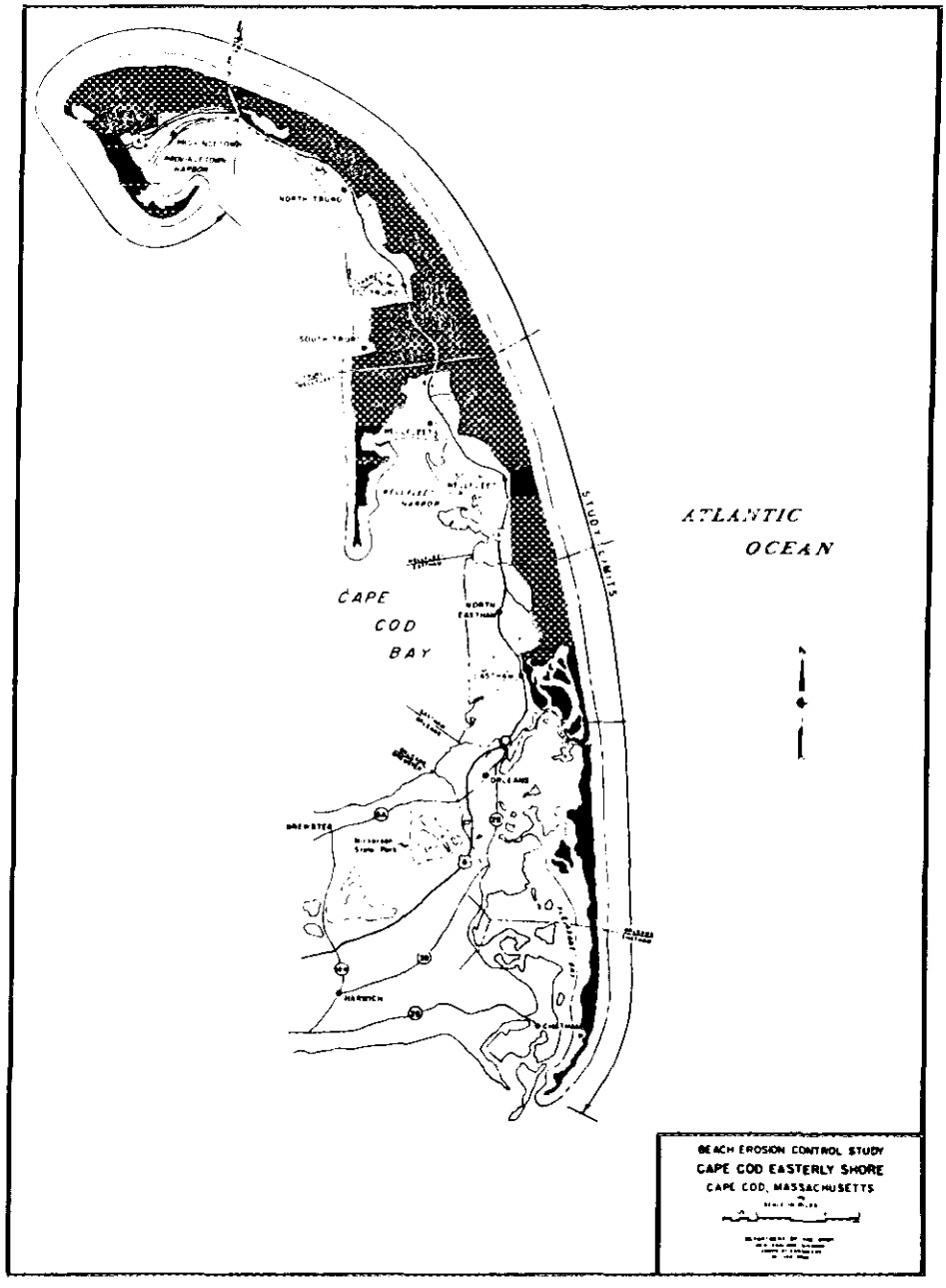


Figure 36. Cape Cod National Seashore boundaries

Table 1. Cape Cod National Seashore

TOWNSHIP	ACRES WITHIN SEASHORE BOUNDARY
Provincetown	7,950
Truro	11,800
Wellfleet	12,300
Eastham	4,800
Orleans	4,100
Chatham	3,650
Total	44,600[1]

[1]Of the 44,600 acres in the National Seashore, 15,400 acres are formally not subject to acquisition according to the legislation which created the Seashore. These acres belong to the State (12,000 acres including tidelands), towns (2,100 acres), and private individuals with dwellings in place before 1 September 1959 (1,300 acres). The Seashore will eventually acquire all the remaining 29,900 acres within its boundary.

The inconsistency between the towns' acreage within the boundary of the Seashore occurs because the Seashore covers tidal areas (lands lying one-quarter mile from shoreline into ocean and bay), while the townships do not.

Source: Cape Cod Planning and Economic Development Commission

Table 2. Present use of Cape Cod National Seashore

CLASS	TYPE	ACRES
1	High-density recreation areas	0
2	General outdoor recreation	4,400
3	Natural environment areas	21,800
4	Outstanding natural features	450
5	Primitive areas	770
6	Historic and cultural sites	240
-	Unclassified - U.S. Route 6	40
	Total	27,700

Source: Master Plan, Cape Cod National Seashore, 1974.

Table 3. Total visits to Cape Cod National Seashore

YEAR	TOTAL VISISTS
1964	1,849,875
1965	2,306,133
1966	2,830,288
1967	3,040,509
1968	3,475,842
1969	4,031,258
1970	3,987,001
1971	4,188,300
1972	4,972,281
1973	4,741,975
1974	4,359,393
1975	5,222,895
1976	5,018,707

Source: National Park Service

The visitor center is located at Eastham. Information concerning facilities throughout the Seashore is available there, and exhibits detailing the history and geology of Cape Cod are displayed in the visitor center museum. The center also contains an auditorium and amphitheater where audio-visual programs are presented.

Numerous trails, located throughout the National Seashore, highlight interesting and unique areas such as the White Cedar Swamp at the Marconi Station site in Wellfleet. Others are the Buttonbush Trail for the Blind, Nauset Marsh and Fort Hill Trail in Eastham, Great Island Trail in Wellfleet, Small's Swamp Nature Trail and Pilgrim Spring History Trail in Truro, and the Beach Forest Trail in Provincetown. Bike paths are established in Eastham and Truro, and at Provincetown a trail through the Provinceland dunes connects the visitor center there with Herring Cove and Race Point beaches. An off-the-road vehicle (ORV) trail is also provided at Provincetown.

The eroding easterly shores of Cape Cod are located within the bounds of the National Seashore. Any plan or plans of improvement involving National Seashore lands will have to conform to National Park Service policy. As a result of detailed scientific studies and experience with costly failures at controlling eroding shorelines, the Service announced in 1973 that it would no longer try to control shoreline processes anywhere along the coastline within its jurisdiction (Giese and Giese, 1974).

BEACHES

The National Seashore beaches include Herring Cove and Race Point beaches in Provincetown, Head of the Meadow and Highland Light beaches in Truro, Marconi Beach in Wellfleet and Nauset Light and Coast Guard beaches in Eastham (Figure 37). (The beach area from Coast Guard Beach to Nauset Harbor inlet has been closed by the Park Service to allow the area to recover from a severe winter storm that caused extensive damage to the spit in February 1978. Parking and bathhouse facilities at Coast Guard Beach were destroyed.) Lifeguards, bathhouse facilities and parking areas are provided at the beaches. The beaches that comprise the National Seashore are discussed in detail in Sections A through F of this Volume. See Location Map Plate No. 1, located in the beginning of this volume for ownership and Park Service boundaries.

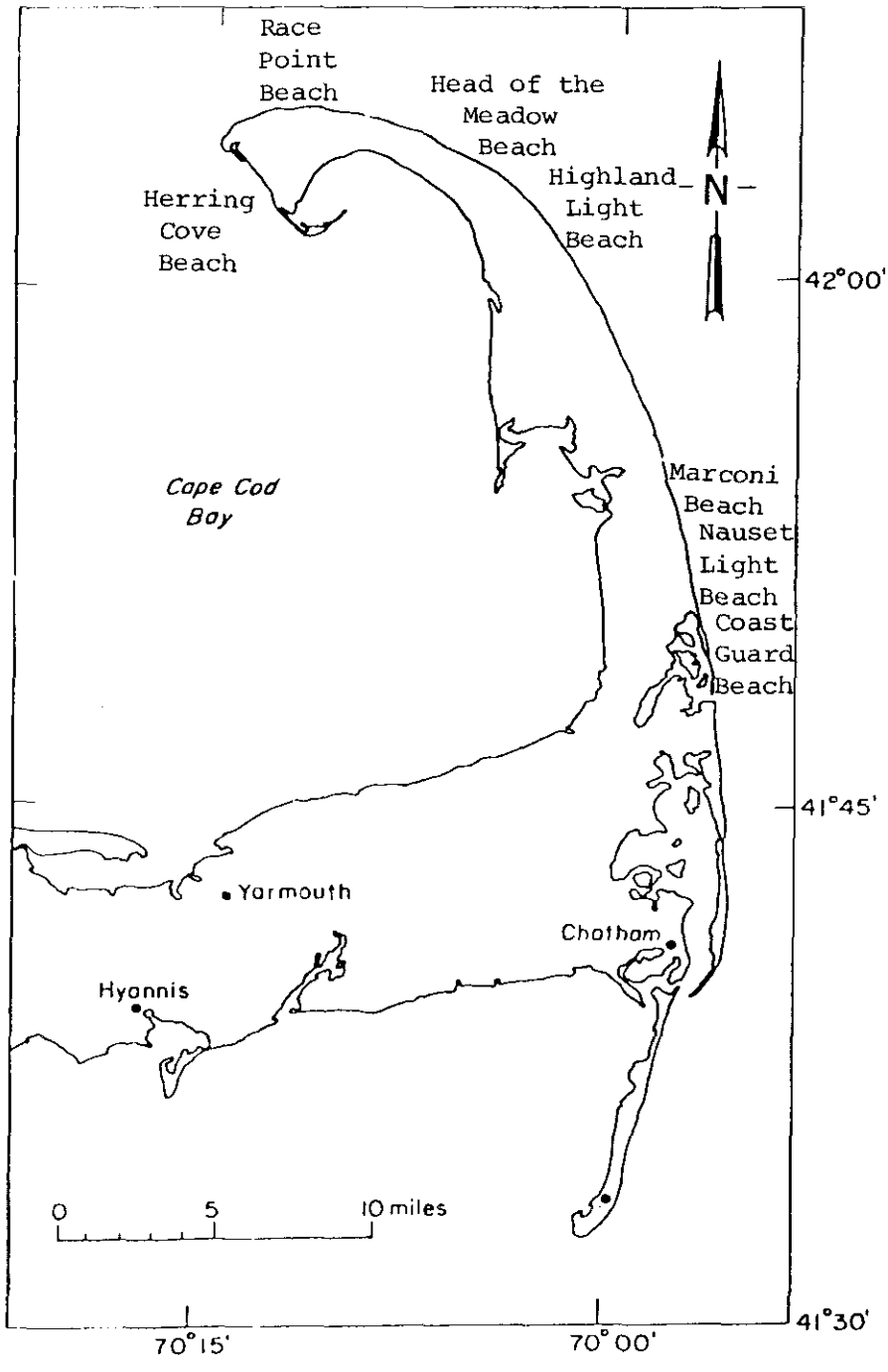
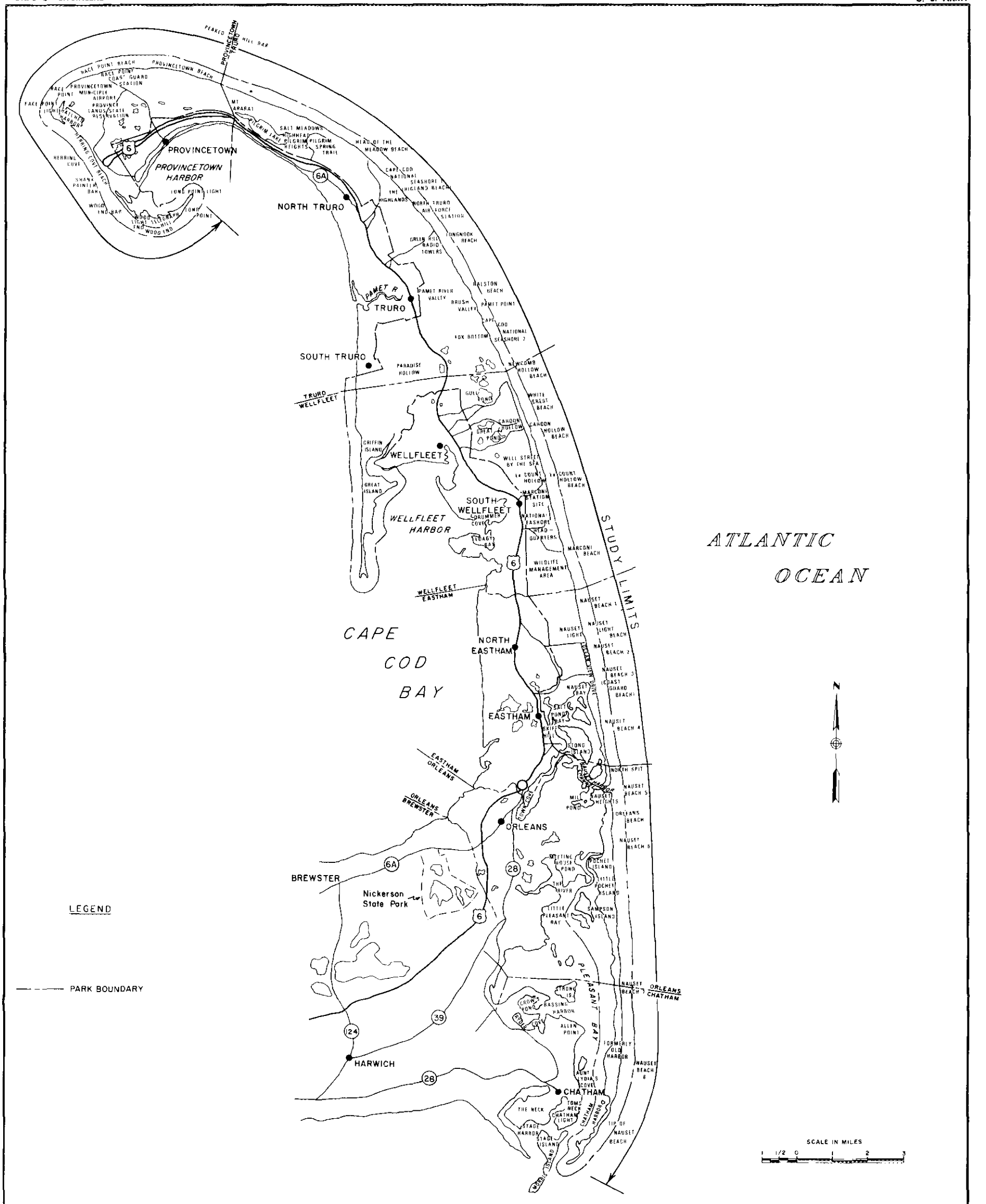


Figure 37. National Park Service Beaches on Cape Cod, Massachusetts



BEACH EROSION CONTROL STUDY

CAPE COD EASTERLY SHORES

CAPE COD, MASSACHUSETTS

MAP OF BEACHES ON OUTER CAPE COD

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE G-1

SECTION H

SHORE STRUCTURES

SHORE STRUCTURES

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SHORE STRUCTURES

INTRODUCTION

Military installations on Cape Cod have provided documentation for shoreline changes on the outer Cape. Active sites include U.S. Coast Guard Lighthouses and/or stations at Long Point, Wood End and Race Point in Provincetown; Highland or Cape Cod Light in Truro; Nauset Light in Eastham; and the U.S. Air Force Station in North Truro (Figure 38). In addition to these active stations, there were 13 Life Saving Stations established between 1872 and 1902 on the outer Cape and Monomoy Island which were operated by the U.S. Life Saving Service until it became part of the U.S. Coast Guard. In addition, the Navy operated a test range in Provincetown, and the Army maintained a base in Wellfleet.

The geology, lithology and shoreline changes in the areas around the military installations are not presented in this section. In the interest of continuity, they are presented in the reconnaissance reports for the towns in which the stations are located.

COAST GUARD INSTALLATIONS

Long Point Light Station

Location and Description - Long Point Light Station is located on the southwest side of the entrance to Provincetown Harbor, on the extreme end of the hook that makes up Provincetown. It is approximately 1.5 miles southeast of the municipal pier and 1.5 miles due east of the northern terminus of the Great Dike. The light, situated atop a square white tower, is 36 feet above the water and is visible for 9 miles.

History - Originally illuminated in 1827, the light identifies the low-lying sand spit that extends around Provincetown Harbor. Before the light's construction, many ships that had misjudged the location of the spit went aground trying to turn into the harbor.

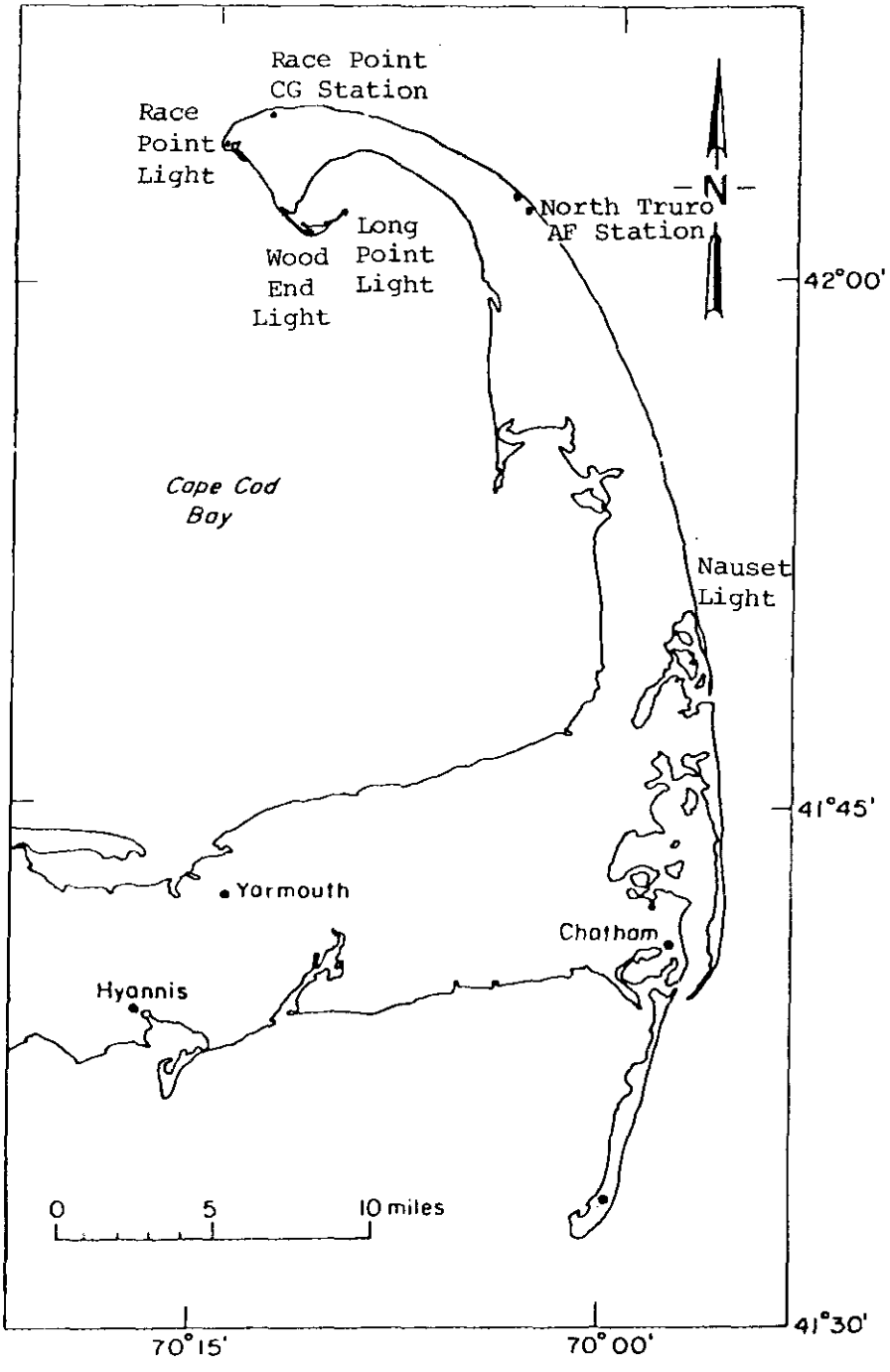

Figure 38. Location map for military facilities on outer Cape Cod, Massachusetts

Wood End Light Station

Location and Description - Wood End Lighthouse, constructed in 1827 by the Commonwealth of Massachusetts, is located 1-1/2 miles due south of Telegraph Hill, Provincetown, on the sand spit extending out to Long Point. The lighthouse was built at this location to guide ships around the treacherous Wood End Bar. Like Long Point, Wood End Lighthouse is a square white tower, and the light, which is 45 feet above the water, is visible for 14 miles.

Wood End Coast Guard Station, which was located approximately 200 feet east of the Light Station, was originally constructed in 1896 as a Life Saving Station to aid the victims of the numerous shipwrecks on Wood End Bar. Even with the lighthouse many wrecks occurred during fog or when ships were forced onto the shoals during storms.

The area surrounding the lighthouse is a low-lying sand spit with dunes reaching a maximum elevation of about 12 feet above mean sea level. Although the area is naturally sheltered from most storms, the spit has been overtopped. The northeaster of February 1978 produced a breach in the bar.

History - Wood End, now a desolate area, was once the site of a small community numbering around 200 people in the 1850s. A large salt works where devices evaporated sea water to collect the remaining salt was the attracting industry. For a short time, a facility for processing whale oil was also located at Wood End. By the outbreak of the Civil War, the discovery of salt mines in New York provided a less expensive way to meet the salt demand, thereby eliminating the market for Wood End salt.

Race Point Lighthouse

Location and Description - Race Point Lighthouse is located at the westernmost extremity of the outer arm of Cape Cod in the Provincelands section of the National Seashore. Hatches Harbor adjoins it to the southeast.

A low-lying beach backed by 10- to 15-foot high dunes adjoins the lighthouse. Although the area is deserted now, it supported several hundred fishermen and their families in the 1830s.

Although large quantities of sand are deposited in the Race Point area, only small changes in the shoreline occur. Much of the sand deposited on the beach is blown inland, where it builds the dunes and causes Hatches Harbor to shoal.

History - The lighthouse, currently unmanned, is owned and operated by the U.S. Coast Guard. It was originally constructed in 1816 as the primary navigation aid for ships rounding the point to or from Provincetown and for ships continuing on into Boston. Race Point was the site of numerous wrecks, particularly as a result of severe northeast storms.

Race Point Coast Guard Station

Location and Description - Race Point Coast Guard Station is located approximately 1/4 mile north of Provincetown Airport, at the site of the former Race Point Life Saving Station. Old Harbor Life Saving Station, originally located on Nauset Beach in Chatham, was transported to Provincetown in 1977. The station was placed on the dunes above Race Point Beach east of the Coast Guard Station in May 1978.

Shoreline changes in this area are discussed in the reconnaissance report for Provincetown.

Highland Light

Location and Description - Highland Light, also known as Cape Cod Light, is located in the Highlands of Truro about 1.5 miles northeast of the settlement of North Truro (Figure 39). The light station, manned and operated by the U.S. Coast Guard, is situated on the high marine scarp overlooking the Atlantic.

The coast at Highland Light trends northwest-southeast. Fetch from the east (at an angle of 45 degrees to the coast) is unlimited; the fetch distance decreases to 150 nautical miles at 90 degrees to the coast and to 100 nautical miles from the north (at an angle of 45 degrees to the coast). High glacial cliffs behind the beach supply sand both to the beach and to the littoral currents that carry the material to the north. Offshore bars are located about 2,000 feet from the beach, and numerous complex bars are located in the nearshore zone (Zeigler et al, 1959).

History - The light station was constructed in 1797 to reduce the large number of shipwrecks in the area. So that it would not need to be moved repeatedly, the lighthouse was situated back from the edge of the bluff. When Highland Light was constructed, the lighthouse was located about 450 feet back from the edge of the bluff; this distance has been reduced to about 200 feet by erosion. Less than 3 acres remain of the original 10 acres on which the lighthouse was constructed. Erosion has removed the rest (Chamberlain, 1964). Many of the outbuildings, including the keeper's house, have been moved several times. Remains of several buildings and foundations are visible on the beach below. Highland Life Saving Station, built in 1872, was located about 0.8 miles west of Highland Light (Dalton, 1902).

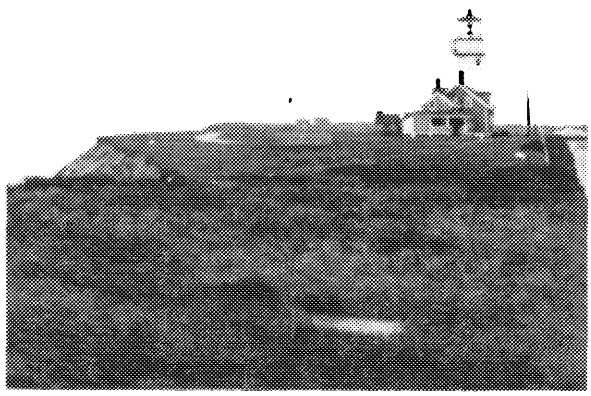

Figure 39. Highland Light, Truro, Massachusetts

Nauset Light

Location and Description - Nauset Lighthouse is located at the end of Cable Road in Eastham, approximately 1 mile north of Nauset Bay on the Atlantic Ocean. The lighthouse is situated about 50 feet above the ocean on a high scarp that is part of the Eastham outwash plain (Figure 40).

History - Originally constructed in 1839 as three brick lighthouses to distinguish it from the twin lights of Chatham, Nauset Light is the only visual navigation aid between Chatham and Highland Light in Truro. The light station was constructed as a result of the numerous wrecks that occurred along the coast north of Nauset Inlet. In 1892 when the three towers toppled into the sea, they were replaced by three wooden towers. These in turn gave way to a single wooden tower in 1911, and in 1923 the present lighthouse was moved to Nauset from Chatham.

Life Saving Stations

Between 1872 and 1902, the U.S. Life Saving Service built 13 Life Saving Stations on Cape Cod to provide assistance to ships that strayed too close to shore or were shipwrecked on the coast (Dalton, 1902). The nine original stations constructed in 1872 were Race Point and Peaked Hill Bars (Provincetown), Highland and Pamet River (Truro), Cahoon's Hollow (Wellfleet), Nauset (Eastham), Orleans, and Chatham and Monomoy (Chatham). Stations added later were High Head in Truro (1883), Wood End in Provincetown (1896) and Old Harbor (1897) and Monomoy Point in Chatham (1902). None of the nine original stations survive.

Late in 1977, erosion threatened the Old Harbor Life Saving Station in Chatham and it was moved to a location adjacent to Race Point Beach in Provincetown, where the National Park Service will maintain it as a life saving museum.

NAVY INSTALLATIONS

The U.S. Navy maintained a Fleet Operational Readiness Accuracy Check Site (FORACS) station at Race Point in Provincetown from the late 1960s to the early 1970s. The facility consisted of three tracking stations and a control center. The control center, which was located on Coast Guard land adjacent to the Coast Guard Station at Race Point, was turned over to the Coast Guard Station when the facility was deactivated. Additional information about this area is contained in the reconnaissance report for Provincetown.

Figure 40. Nauset, Eastham, Massachusetts

ARMY INSTALLATIONS

Camp Wellfleet, presently the site of the National Seashore Headquarters, was formerly a U.S. military reservation that extended along the Atlantic shore from South Wellfleet to the Wellfleet-Eastham town line. Additional information on this area can be found in the reconnaissance reports for Wellfleet and Marconi Beach.

AIR FORCE INSTALLATIONS

The U.S. Air Force maintains a radar station that occupies approximately 125 acres at the top of the marine scarp on the Atlantic coast of Cape Cod at North Truro. Elevation of the scarp varies from 125 to 160 feet in the area of the station. The Air Force also maintains another smaller site, the Green Hill radio towers, about 1 mile south of the North Truro station.

Information on this area can be found in the reconnaissance report for Truro.

SECTION I

NAUSET HARBOR INLET

NAUSET HARBOR INLET

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NAUSET HARBOR INLET

A survey report on Nauset Harbor was prepared by the New England Division of the Corps of Engineers in 1969. Much of the material presented in this section was obtained from that report.

LOCATION AND DESCRIPTION

Nauset Harbor inlet (Figure 41) is located on the Atlantic coast of Cape Cod in the towns of Eastham and Orleans, Massachusetts. Nauset Harbor is bounded on the north and west by the town of Eastham, on the south by the town of Orleans and on the east by Nauset Beach and the Atlantic Ocean (U.S. Army Corps of Engineers, 1969).

The inlet, which is located between two migrating spits, connects Nauset Harbor with the Atlantic Ocean. It is the only inlet on the eastern shore of Cape Cod between Chatham Harbor and Provincetown Harbor. The location of the inlet changes with time in response to the migration of the spits. Natural channels in the inlet shift rapidly, making navigation hazardous.

Nauset Beach in the area of Nauset Harbor consists of two spits, one extending south from the scarp area below Nauset Light and the other extending north from Nauset Heights. The north spit at Nauset Harbor inlet consists of 10- to 15-foot high sand dunes with numerous washovers including one at Coast Guard Beach (at the northern end of the spit) which was leveled by a storm in February 1978. The southern section of the north spit is flatter with less vegetation. Due to the damage caused by winter storms during 1977-78, the National Park Service has closed the area to traffic in an attempt to aid recovery of the vegetation. South of the inlet, the southern spit varies in width from about 500 to 800 feet and 10-foot dunes exist on the southern section. Longshore transport of material eroded from the scarp area to the north nourishes the beaches of the north spit. Some of the sand moving south along the coast is introduced into the harbor through the inlet. Large quantities of sand are also carried across the barrier beach by washovers and eolian transport.

STATEMENT OF THE PROBLEM

Navigation through the inlet to Nauset Harbor is hampered by the shoaling and shifting of natural channels which reduce its usefulness for commercial

Figure 41. Nauset Harbor Inlet, Cape Cod, Massachusetts

and recreational craft and as a harbor of refuge. Washovers and eolian transport introduce large amounts of sand into Nauset Bay and Harbor, filling navigation channels and covering shellfish beds.

Improvements desired by the local towns include a stabilized inlet, an entrance channel, anchorage areas, nourishment of the outer beach and maintenance of interior channels to prevent shoaling and stagnation problems. The desire for improvements is partly motivated by economic considerations because the local economy is dependent on tourists, many of whom are attracted to the area by the recreational opportunities afforded by Nauset Bay.

HISTORY

Erosion of the scarp north of Nauset Bay and southward transport of sediment eroded from the scarp, particularly during northeast storms, supplied the material to build Nauset Beach. Marshes were formed in the bay behind the spit, and the uplands behind the barrier beach/marsh complex were protected from wave attack.

Nauset Harbor was at one time connected with Cape Cod Bay by a narrow ditch that became known as Jeremiah's Gutter in honor of a previous owner, Jeremiah Smith. In 1804 the Eastham-Orleans proprietors dug a small canal through the marsh. Although used for transshipment of goods during the War of 1812, the canal never succeeded because of the dangers of navigating through Nauset Harbor inlet. The ditch gradually filled in and was finally sealed with the construction of a dike by the Commonwealth of Massachusetts.

In 1854 Nauset Harbor was also connected with Pleasant Bay. Beach recession filled the connecting waterway and a large, paved parking lot that serves Orleans Town Beach was constructed over the filled area (U.S. Army Corps of Engineers, 1969).

In 1966 efforts were initiated to slow the erosion at Coast Guard Beach at the northern end of the north spit. From 1966 to 1972, a total of 10,000 cubic yards of rubble was placed in front of the bathhouse and parking lot. The rubble became hazardous to swimmers and appeared to accelerate erosion in adjoining areas and was subsequently removed. Erosion has continued at Coast Guard Beach and during a storm in February 1978 damaged the bathhouse and parking lot, and an extensive washover was formed.

Dune building experiments were also conducted along the north and south spits. In 1969 a project was initiated at the north spit of Nauset Harbor inlet. American beach grass, straight sand fence, sand fence with side spurs and fabric fence were installed. During the first year of the experiment, Nauset Harbor inlet migrated north, destroying one section of fence. Anticipated migration of the inlet coupled with loss of beach grass caused

the site to be abandoned and the experiment was relocated to the southern spit. Beach grass, straight fencing and fencing with spurs were tested for sand-trapping ability. Sand was accumulated by all sections of grass and fence, and straight sand fence stabilized with beach grass produced the greatest accumulation.

RATE OF MIGRATION

Zeigler and his associates (Zeigler et al, 1964a) in investigating shoreline recession along the outer Cape Cod coast found that

> . . .Nauset Spit on the south end of our survey was being driven into the marshes at approximately 5 feet per year but we do not think this is a valid figure. At about the time the surveying was being done, Nauset Spit was cut by a series of breakthroughs and coastal adjustments were rapid. We have observed no serious bending of this spit in the years following our survey and therefore we assume Nauset Spit must be retreating at the same rate as the cliffs.

Migration rates for this inlet cannot be determined accurately. Its location remained stable from at least 1887 until 1938. After 1938 growth of the southern spit caused the inlet to migrate more than a mile to the north. Therefore, long-term or short-term rates of inlet migration can be misleading.

SHORELINE CHANGES

The shoreline at Nauset Harbor is constantly changing as the inlet to the harbor migrates north and south and the barrier beach migrates landward. Prior to 1938 (Figure 42), the inlet was located at Nauset Heights and no southern spit existed. As the southern spit formed and grew, the inlet migrated northward. In September of 1977, the southern spit was more than a mile in length.

Northeast storms have caused radical changes in spit length at Nauset Harbor inlet. Due to a series of storms between October 1957 and April 1958, the length of the south spit at Nauset Harbor inlet was reduced from 4,050 feet to 1,850 feet. The reduction in length resulted from a disintegration of the spit and the formation of a new breakthrough (Zeigler, 1958). Since the severe changes of 1957-58, the south spit has again grown northward. Between 1967 and 1977 the south spit grew approximately 3200 feet, about 311 feet per year. Location of the inlet could be drastically changed if erosion at Coast Guard Beach were to cause a breach in the northern spit, producing a new inlet to Nauset Bay (Fisher, 1972).

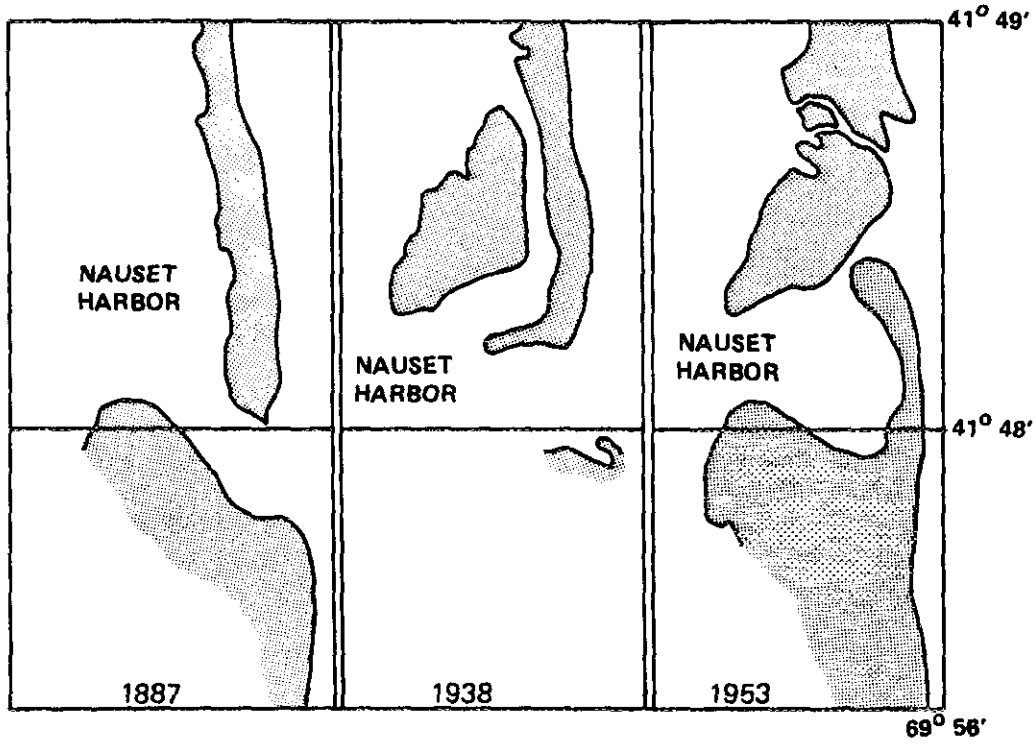

Figure 42. Shoreline changes at Nauset Harbor Inlet, 1887-1953 (after Zeigler, 1956)

Landward migration of the north spit at Nauset Harbor inlet occurs as eolian transport, overtopping and tidal transport through the inlet move sand from the seaward to the landward side of the barrier beach. Sand transport by washover processes was graphically illustrated during the winter of 1977-78 when overtopping leveled Coast Guard Beach at the northern end of the north spit.

METHODS OF CORRECTING THE PROBLEM

In 1969 the New England Division of the Corps of Engineers undertook a study of the Nauset Harbor inlet area. To correct existing navigational problems and to accommodate the existing and anticipated commerical and recreational demand, they proposed a plan of improvement that included a new, stabilized inlet through Nauset Beach protected by two jetties; an entrance channel into Mill Pond; and branch channels in the Salt Pond River and along Hopkins Island, both terminating at small anchorage areas. The cost in 1969 (estimated at over 8 million dollars) could not be justified based on the anticipated benefits that the improvements would provide (U.S. Army Corps of Engineers, 1969).

Several factors that influenced the study's outcome are pertinent to any plan or structure proposed for this area. Because large amounts of material are in transit along the beach, any plan such as one involving jetties that would interrupt the littoral drift would require periodic bypassing of the sand. Maintenance of channels within Nauset Harbor and adjacent areas is closely related to provision of a safe access to the harbor and to the integrity of the barrier beach (U.S. Army Corps of Engineers, 1969). Providing access to and maintaining access in Nauset Harbor would involve high initial costs and high annual costs.

Additional considerations addressed by the U.S. Fish and Wildlife Service, Massachusetts Division of Marine Fisheries and Eastham's Natural Resource Department concerning disposal of dredge spoils are also pertinent, because any proposed project would probably require dredging. The U.S. Fish and Wildlife Service suggested that no spoil material should be deposited on the marshes or mud flats or in any waters inside the inlet. Such disposal could harm the extensive lobster nursery and shellfish populations found in the marshy areas of Nauset Bay. Any improvements that would increase the number of boats using the inlet area should be evaluated in terms of possible pollution that could result and its impact on the fish and wildlife of the area (U.S. Army Corps of Engineers, 1969).

SECTION 3

OLD HARBOR

OLD HARBOR

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OLD HARBOR

This reconnaissance report includes a description of the shoreline changes at the former site of the Old Harbor Life Saving Station, and the problems of Pleasant Bay and Chatham Harbor caused by erosion of Nauset Beach. Further information on these areas can be found in the reconnaissance reports for Orleans and Chatham.

LOCATION AND DESCRIPTION

Pleasant Bay, a shallow salt water lagoon, is located in the towns of Orleans, Harwich and Chatham at the "elbow" of Cape Cod (Figure 43). Little Pleasant Bay and Chatham Harbor are adjacent to it. The harbor and bay complex is bounded on the north by the town of Orleans, on the west by the towns of Orleans, Harwich and Chatham, on the south by Nantucket Sound and Monomoy Island, and on the east by the Atlantic Ocean and Nauset Beach (U.S. Army Corps of Engineers, 1968).

Chatham Harbor, a narrow passage about 4 miles long and one-half mile wide, connects Pleasant Bay with the Atlantic Ocean. The combined area of Chatham Harbor and Pleasant Bay is approximately 7,400 acres (U.S. Army Corps of Engineers, 1968).

The entrance to Chatham Harbor was previously located to the north of its present location at a site southeast of Allen's Point known as Old Harbor. When Old Harbor Life Saving Station was constructed in 1897, it marked the terminus of the south spit of Nauset Beach and the main channel to Pleasant Bay. The station was built to serve as a rescue base for victims of shipwrecks along the south spit and within the harbor area.

Nauset Beach is a low, sandy spit about 8 miles long extending south from Nauset Heights. Dunes are found on the northern end of the spit, but because of the relatively recent origin of the southern end of the spit, large dunes are not generally found in this area. Overtopping during storms and the formation of washovers are common (U.S. Army Corps of Engineers, 1968).

Monomoy, now an island, extends about 8 miles south from the mainland of Cape Cod into Nantucket Sound. Prior to the winter of 1957-58, Monomoy was attached to the southern coast of Chatham but winter storms separated Monomoy from Morris Island, leaving tidal flats (U.S. Army Corps of Engineers, 1968). The separation was completed by the Great Atlantic Storm of March 1962 (Gatto, 1975).

Figure 43. Pleasant Bay and Chatham Harbor, Cape Cod, Massachusetts

STATEMENT OF THE PROBLEM

The barrier beach - barrier island system that makes up Nauset Beach and Monomoy Island has undergone extensive change during recorded history. Cycles of inlet migration have caused the entrance to Chatham Harbor and Pleasant Bay to shift radically (Goldsmith, 1972). Mariners using Chatham Harbor desire a stabilized inlet with a permanent, maintained channel (U.S. Army Corps of Engineers, 1968).

In addition to the inlet migration, the barrier beach complex is also migrating landward. Washovers carry large quantities of sand from the ocean to the bay when the beaches and dunes are overtopped during storms. Additional sand is moved across the barrier beach by winds. Problems resulting from sand transport in this area were summarized by the U.S. Army Corps of Engineers (1968):

> The primary difficulty attending navigation at Pleasant Bay is the increasing inability of commercial fishing craft to navigate the Chatham Harbor inlet at low water. Since winter storms breached Monomoy Island in 1957-1958, the natural channel into Chatham Harbor began to shoal badly and an offshore bar formed at the mouth of the inlet. The depth of water was reduced from about 18-20 feet to about 4-5 feet over the bar and became extremely hazardous to navigation. Fishermen feared to navigate the shifting channel and shallow bar at low water, and tidal delays of several hours became common. Breaking waves over the inlet bar from distant storms also keep the fishermen in port on good days. There were so many near mishaps that local fishermen appeared before the Massachusetts Marine Fisheries Advisory Commission in April 1965 to request that emergency measures be taken to close the Monomoy Island breach by either State or Federal authorities. . .
>
> Storm waves fill and shift natural channels and make navigation practically impossible at low stages of the tide and hazardous at high tide. The littoral drift from the outer beach moves southerly toward the existing inlet, where a portion forms a submarine bar across the existing Chatham Harbor inlet. Flood tides also carry large volumes of drift into Chatham Harbor and Pleasant Bay. "Flood-tide channels" formed in Chatham Harbor make navigation difficult even by local boatmen. The finer material settles out at slack periods in the upper bay, covering valuable shellfish beds. Shoals so formed also restrict recreational boating in that area. The ebb tides cause extensive meandering of the inlet channel and also carry some material back out of the harbor where it is deposited in a large shoal area offshore and south of the inlet. In addition to inlet shoaling, winter storms periodically overtop Nauset Beach and wide washovers are created through the dunes. This results in large quantities of sand being carried into Pleasant Bay, thereby contributing to shellfish bed covering and shoaling natural navigation channels. (U.S. Army Corps of Engineers, 1968)

HISTORY

Built in 1897 Old Harbor was one of 13 Life Saving Stations constructed on the outer coast of Cape Cod to provide assistance to victims of the frequent wrecks along the shore of the outer Cape. Old Harbor continued to be used even after the harbor entrance had moved south. However, the advent of modern navigation equipment and the opening of the Cape Cod Canal reduced the need for its services and the Coast Guard abandoned the station in 1944. Erosion and winter storms threatened to destroy this historic structure, so in November 1977 the station was moved by barge to Provincetown. In May 1978 Old Harbor Life Saving Station was placed on the bluff overlooking Race Point Beach where it will be maintained by the National Park Service as a life saving museum.

SHORELINE CHANGES

The inlet migration cycle identified by Goldsmith (1972) began in 1846 when the inlet was in the same location as it was in 1971. A breakthrough was formed in 1846 and a new entrance to Pleasant Bay was formed. The spit on which Old Harbor Life Saving Station was built grew southward (Figure 44), extending approximately 6 miles south of its location in 1846 (Goldsmith, 1972).

Westward migration of the barrier beach has been evident at the Old Harbor Life Saving Station site. At the time of construction of the station, the spit was approximately 1100 feet wide at the southernmost extension of the spit. The station was constructed about 500 feet north of the tip and approximately in the center of the spit. In 1910 a Coast Guard survey showed that the station was 600 feet from the mean high water line on the Atlantic Ocean side. In 1940 approximately 1000 feet of dry beach existed on the Atlantic Ocean side of the station, with 10- to 12-foot high dunes. By 1966 only 100 feet remained between the building and the high-water line and by 1977 waves were breaking against the foundation of the Old Harbor Station.

Between 1887 and 1961, the Atlantic shoreline of Nauset spit north of the Old Harbor site gradually shifted 400 to 750 feet westward. The shoreline between the Old Harbor site and the recurved part of the 1940 spit shifted westward about 600 feet between 1940 and 1961 (Oldale and Koteff, 1970).

Between 1938 and 1971, deposition and southerward migration occurred at the tip of Nauset spit (Gatto, 1975). In 1968 the spit was being extended south at about 250 feet per year (U.S. Army Corps of Engineers, 1968). However, by 1974 the southward migration had stopped and the tip had migrated northward almost 0.5 mile (Gatto, 1975).

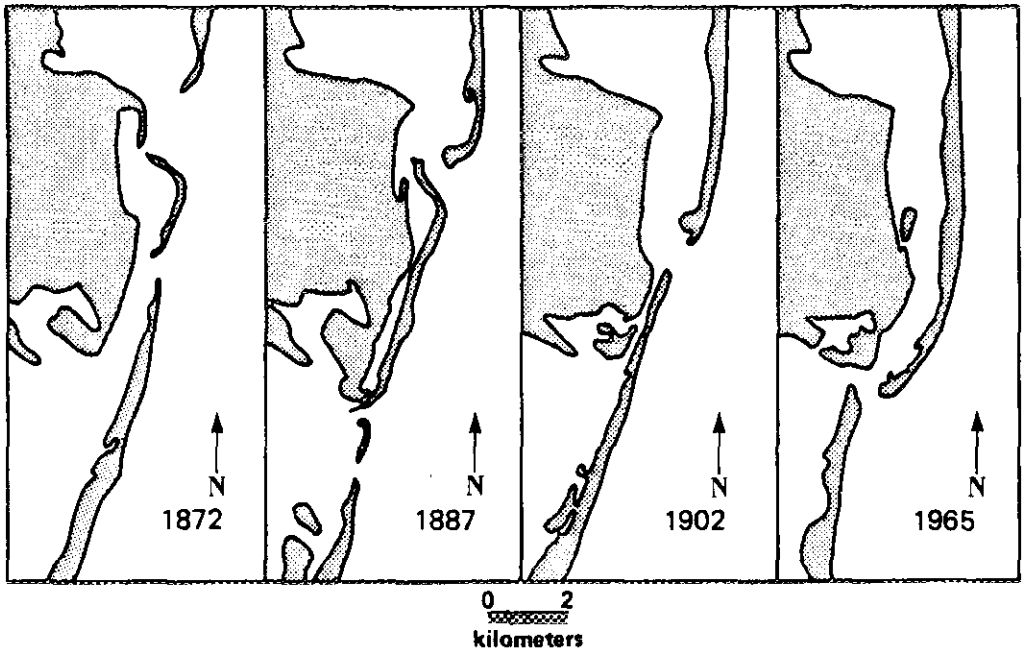

Figure 44. Migration of the tip of Nauset Beach, Chatham, and the inlet to Chatham Harbor and Pleasant Bay (after Hayes, 1972)

Monomoy has also undergone large-scale changes that include separation from the mainland, westward movement of the shoreline, and southward growth of the southern tip. Monomoy Island was originally connected to Morris Island. The gap separating Monomoy from Morris Island was formed as a result of the storms during the winter of 1957-58 and subsequent wave and tidal action (U.S. Army Corps of Engineers, 1968).

Rapid growth of the southern tip occurred between 1856 and 1868 when it grew at a rate of 157 feet per year (Strahler, 1966). However, between 1971 and 1974, the southern tip of Monomoy was eroded (Gatto, 1975), a trend also seen at the southern tip of Nauset Beach.

Further information on shoreline changes at Monomoy can be found in Volume II of this report.

RATES OF MIGRATION AND EROSION

On Nauset Beach near the Old Harbor Life Saving Station site, erosion rates were found to be 16.7 and 19.5 feet per year between 1938 and 1974 (Gatto, 1975). Erosion of 25 feet per year prevailed on parts of Nauset Beach between 1940 and 1968. The material eroded was estimated to be 400,000 cubic yards (U.S. Army Corps of Engineers, 1968).

Erosion rates and migration rates are highly variable in the Nauset/Monomoy area due to the changeable nature of barrier beaches. As the discussion of shoreline changes showed, the spits undergo periods of southerly growth, followed in some cases by northward retreat. Inlets migrate, sometimes following a cyclic pattern. The barrier beach continues to recede shoreward, but its migration rate is unpredictable.

METHODS OF CORRECTING THE PROBLEM

Numerous efforts have been made to build dunes on the washover areas on Nauset Beach, particularly in the vicinity of Old Harbor. The Massachusetts Beach Buggy Association, the New England Division of the U.S. Army Corps of Engineers, the Wellfleet Job Corps, the University of Massachusetts and concerned local citizens have been involved in efforts to build and stabilize dunes. Christmas trees, sand fencing and beach grass have been utilized to collect windblown sand. (See Volume II of this report for a discussion of efforts to inhibit erosion.)

Stabilizing and maintaining a more permanent entrance channel to Pleasant Bay and Chatham Harbor have also been investigated (U.S. Army Corps of Engineers, 1968). The plans were designed to improve navigation between Chatham Harbor and the Atlantic Ocean, between Chatham Harbor and Nantucket Sound, and within Chatham Harbor and Pleasant and Little Pleasant Bay. The plans included closing the existing gap between Nauset Beach and Monomoy Island and providing a stabilized inlet through Nauset Beach at a point farther north in Chatham. Navigation channels would be dredged in Chatham Harbor, Pleasant Bay and Little Pleasant Bay as well as into some of the adjoining coves. Although this project, proposed in 1968, could be justified on economic grounds, the total cost was in excess of 15 million dollars at that time, requiring a local contribution of nearly 5 million dollars.

Landward and inlet migration are dynamic natural processes. Any efforts to prevent landward migration of the barrier beach or to provide a stabilized inlet will be costly and probably temporary. Plans of improvement that involve disrupting the barrier beach may hasten the erosion in this area and alter the inlet dynamics.

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